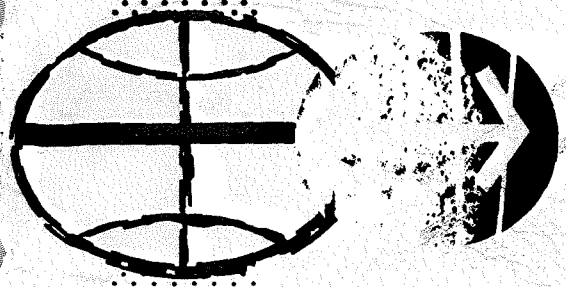
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Early Apollo Scientific Experiments Payload

EASEP Familiarization Course Handout

15 February 1969
Contract NAS9-5829 (SA-65)



Prepared for
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

Bendix Aerospace Systems Division

Early Apollo Scientific Experiments Payloads

EASEP Familiarization Course Handout

For Training Purposes Only

15 February 1969
Contract NAS9-5829(SA-65)

BSR 2601

Prepared for
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

by

Aerospace Systems Division

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EARLY APOLLO SCIENTIFIC EXPERIMENTS PAYLOAD

- SYSTEM OBJECTIVES
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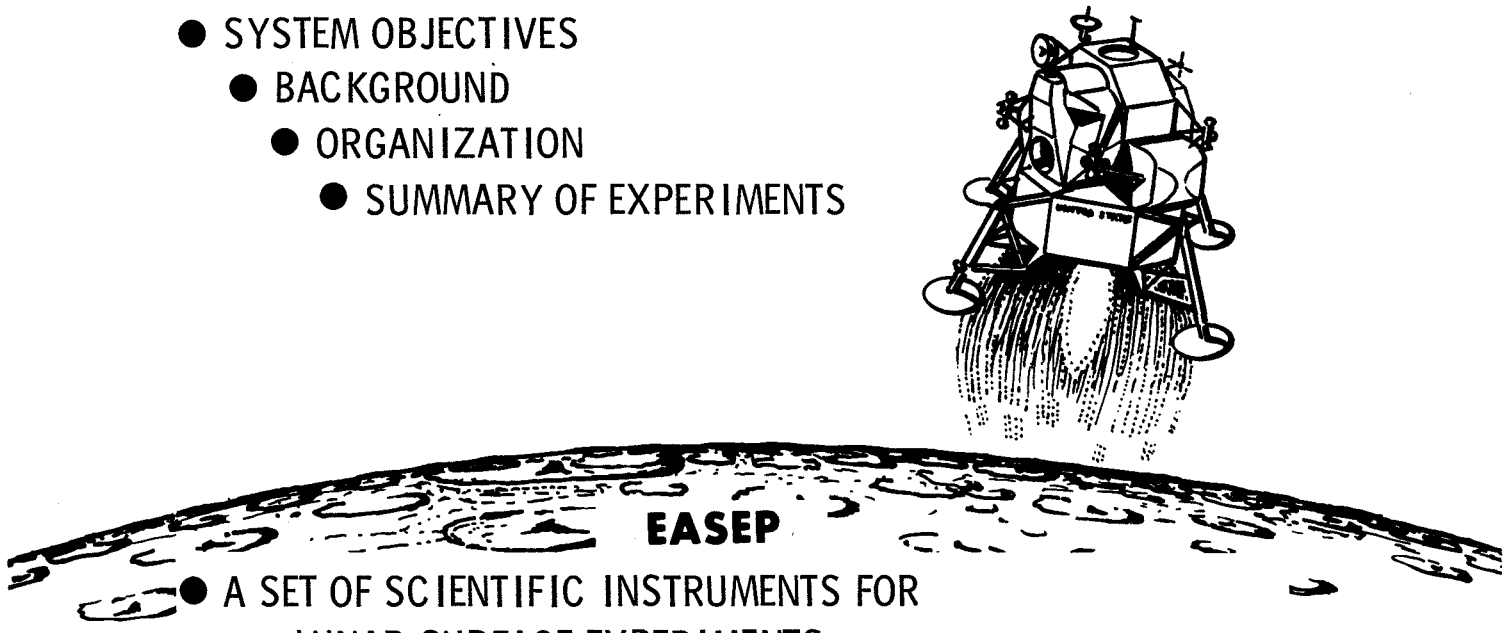

- A SET OF SCIENTIFIC INSTRUMENTS FOR LUNAR SURFACE EXPERIMENTS
- TO BE CARRIED ON APOLLO 11 AND DEPLOYED BY ASTRONAUT
- POST-DEPLOYMENT OPERATIONS THROUGH EARTH-BASED STATIONS

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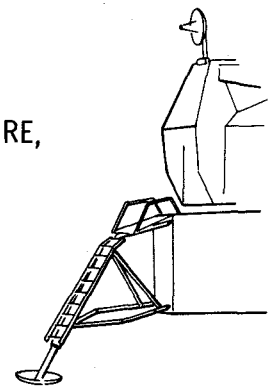
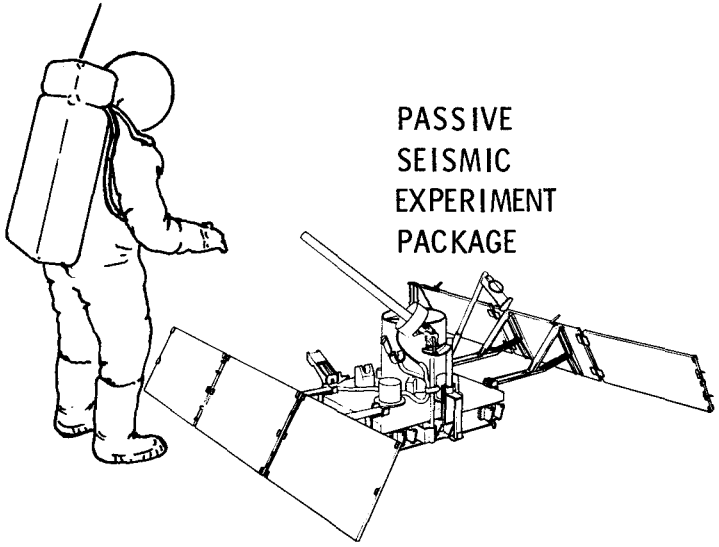
EASEP SYSTEM OBJECTIVES

TO INVESTIGATE:

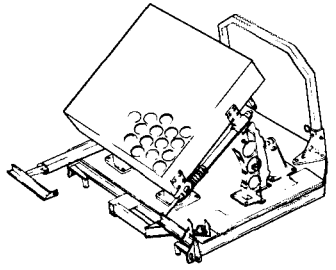
- THE MOON'S INTERNAL STATE, COMPOSITION AND STRUCTURE, AND EVOLUTION OF SURFACE FEATURES
- EARTH-MOON DYNAMIC RELATIONSHIPS





PASSIVE
SEISMIC
EXPERIMENT
PACKAGE

LASER
RANGING
RETRO-REFLECTOR



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EASEP/ALSEP HISTORY AND PLAN

JUNE 1965 - WOODS HOLE CONFERENCE ESTABLISHED SCIENTIFIC GOALS

JULY 1965 - FALMOUT CONFERENCE SCREENED SCIENTIFIC PROPOSALS

APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE(ALSEP)

AUG 1965 - NASA STARTED PRELIMINARY DESIGNS (THREE CONTRACTORS)

MARCH 1966 - START OF DEVELOPMENT PROGRAM TO BUILD FOUR FLIGHT ARTICLES (BENDIX PRIME CONTRACTOR)

JULY 1968 - DELIVERY OF FIRST FLIGHT ARTICLE

OCT 1968 - DELIVERY OF SECOND FLIGHT ARTICLE

EARLY APOLLO SCIENTIFIC EXPERIMENT PAPLOAD (EASEP)

OCT 1968 - START OF EASEP DEVELOPMENT USING PARTS OF SECOND ALSEP PLUS NEW EQUIPMENT

THIS SIMPLIFIED PACKAGE WILL ALLOW THE ASTRONAUTS TO CONCENTRATE ON MAKING A SAFE LUNAR TRIP AND WILL PRODUCE IMPORTANT SCIENTIFIC DATA LONG AFTER THE FLIGHT

PLANNED MISSION ASSIGNMENTS

APOLLO 11: EASEP

APOLLO 12: ALSEP A

APOLLO 13: ALSEP B

APOLLO 14: ALSEP C

} CONTAIN 8 DIFFERENT EXPERIMENTS IN SETS OF 4/FLIGHT

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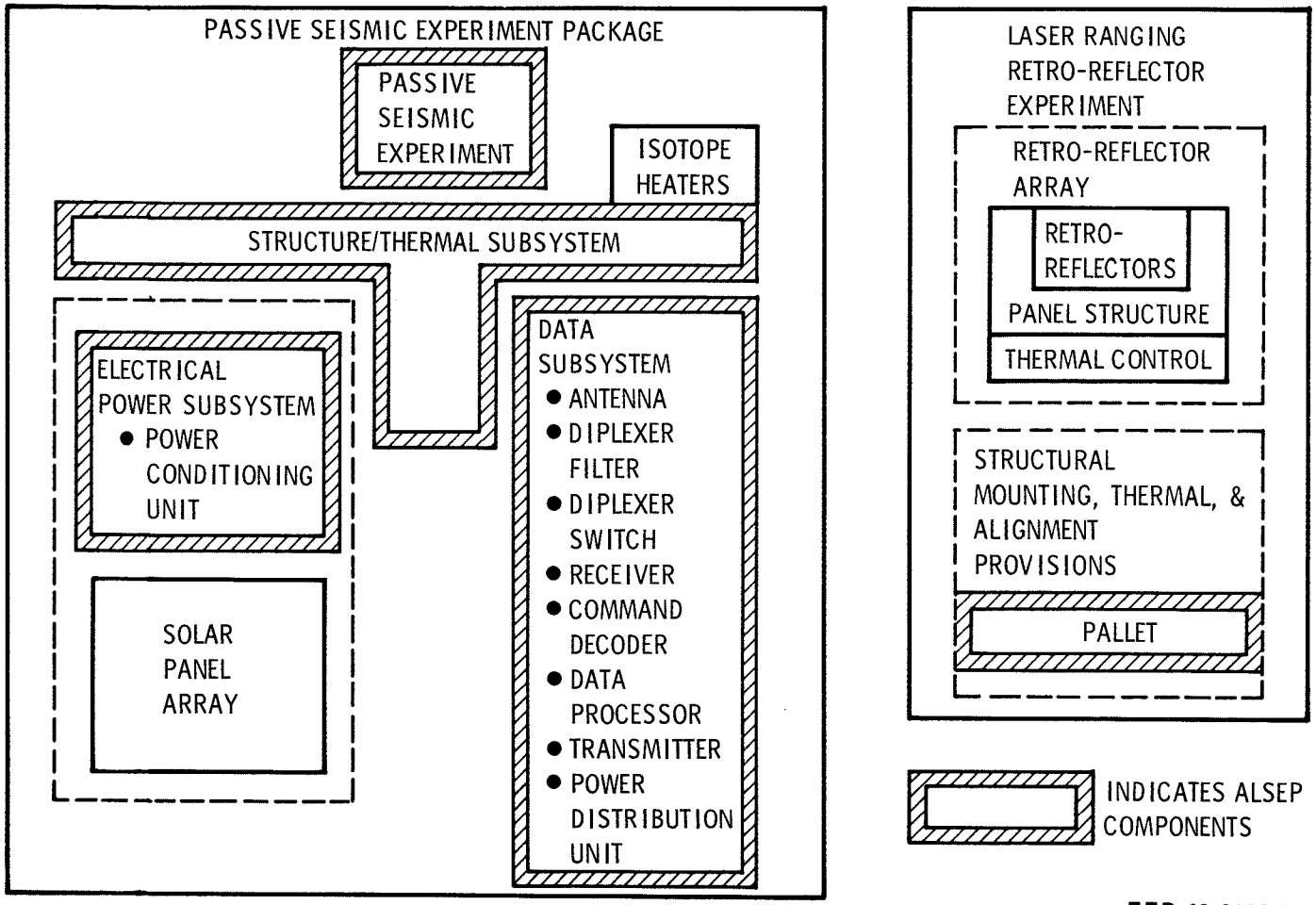
EASEP EXPERIMENTS

NASA NUMBER	S031	S078
NAME	PASSIVE SEISMIC EXPERIMENT	LASER RANGING RETRO-REFLECTOR
PRINCIPAL INVESTIGATOR	DR. G. V. LATHAM, COLUMBIA UNIV	DR. C. O. ALLEY, UNIV OF MARYLAND

COMPONENTS OF EASEP



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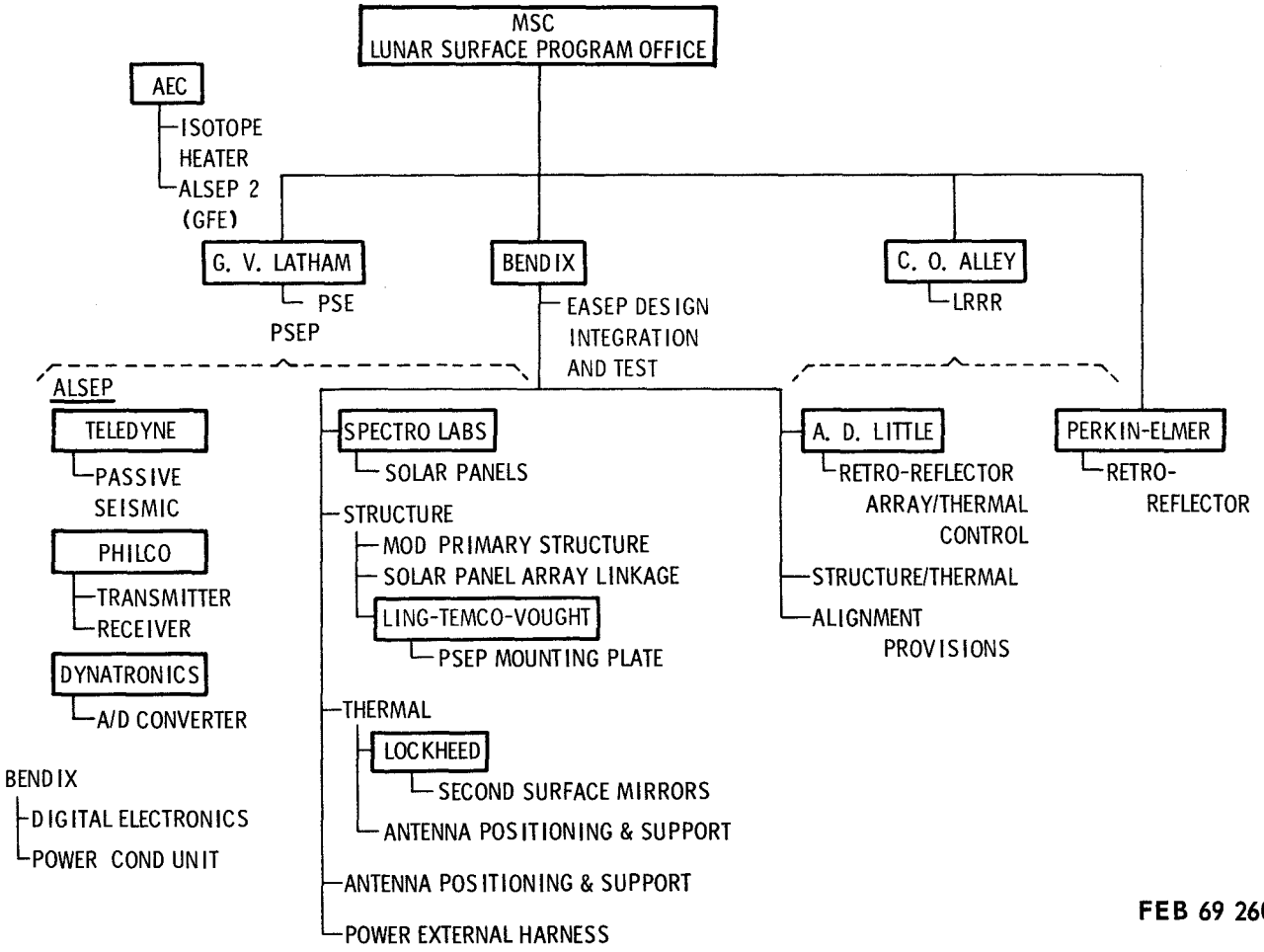
EASEP ORGANIZATION



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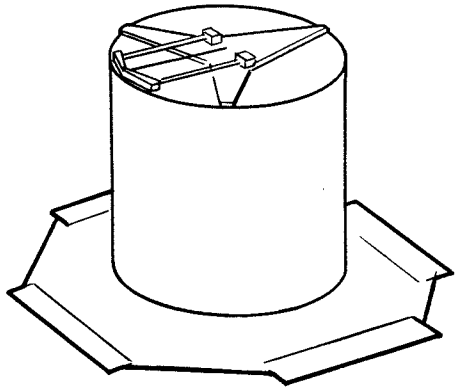
PASSIVE SEISMIC EXPERIMENT
NASA No. SO31

OBJECTIVE: INTERNAL SEISMIC ENERGY & STRAIN REGIME, OVERALL PHYSICAL PROPERTIES (CORE/MANTLE, etc.), DISTANCE & DIRECTION TO EPICENTERS FOR CORRELATION WITH SURFACE FEATURES.

MEASUREMENT: NATURAL SEISMIC WAVE VELOCITY, FREQUENCY, AMPLITUDE & ATTENUATION; FREE OSCILLATIONS & TIDAL DEFORMATIONS

EQUIPMENT: ONE VERTICAL SHORT - PERIOD ELEMENT, THREE ORTHOGONAL LONG-PERIOD ELEMENTS



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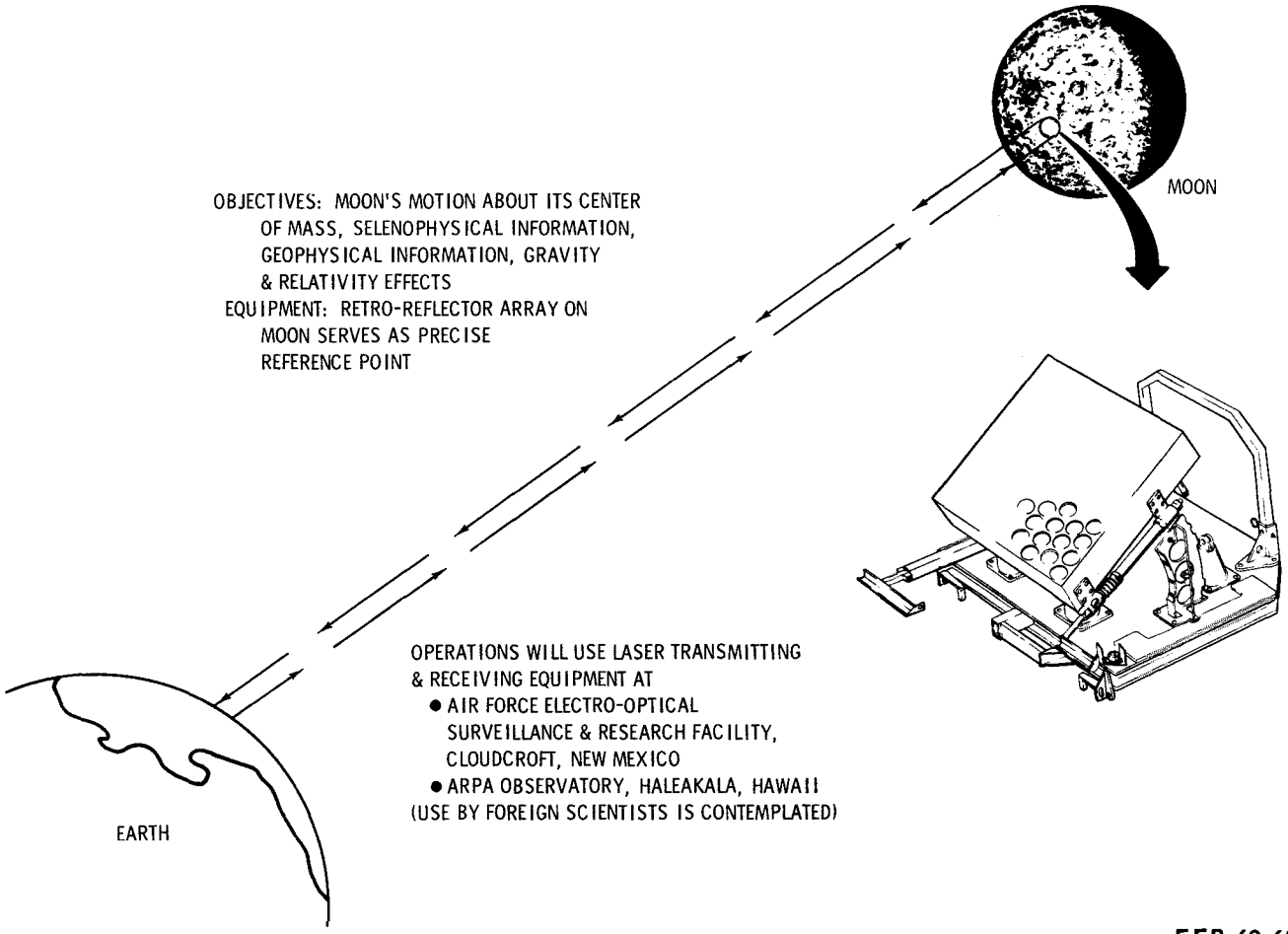
LASER RANGING RETRO-REFLECTOR
NASA No. SO78



OBJECTIVES: MOON'S MOTION ABOUT ITS CENTER OF MASS, SELENOPHYSICAL INFORMATION, GEOPHYSICAL INFORMATION, GRAVITY & RELATIVITY EFFECTS

EQUIPMENT: RETRO-REFLECTOR ARRAY ON MOON SERVES AS PRECISE REFERENCE POINT

OPERATIONS WILL USE LASER TRANSMITTING & RECEIVING EQUIPMENT AT

- AIR FORCE ELECTRO-OPTICAL SURVEILLANCE & RESEARCH FACILITY, CLOUDCROFT, NEW MEXICO
- ARPA OBSERVATORY, HALEAKALA, HAWAII

(USE BY FOREIGN SCIENTISTS IS CONTEMPLATED)

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ALSEP EXPERIMENT ASSIGNMENTS

NASA NO.	EXPERIMENT	ABBR.	ALSEP NUMBER		
			A	B	C
S031	PASSIVE SEISMIC	PSE	X	X	X
S033	ACTIVE SEISMIC	ASE			X
S034	LUNAR SURFACE MAGNETOMETER	LSM	X		
S035	SOLAR WIND SPECTROMETER	SWS	X		
S036	SUPRATHERMAL ION DETECTOR	SIDE	X		X
S037	HEAT FLOW	HFE		X	
S038	CHARGED-PARTICLE LUNAR ENVIRONMENT	CPLEE		X	X
S058	COLD CATHODE GAUGE	CCGE		X	

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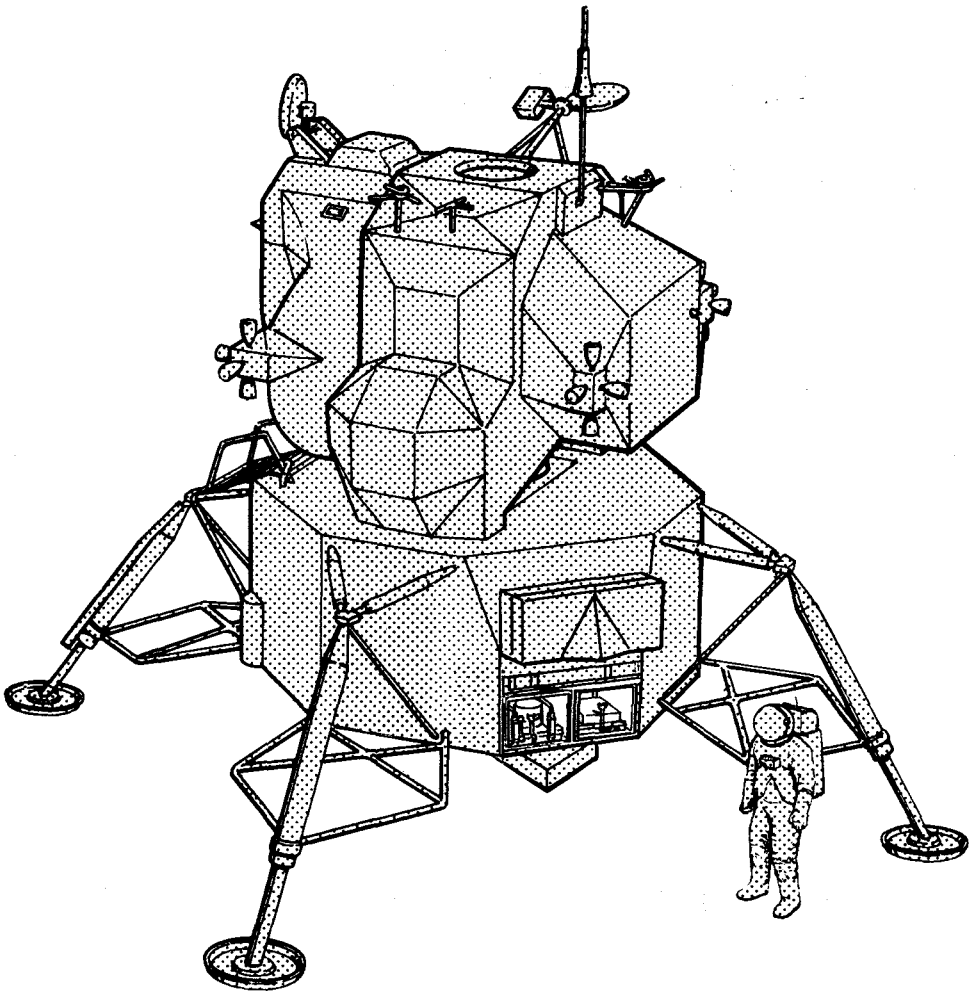
SYSTEM REQUIREMENTS AND CONSTRAINTS

- LM INTERFACES
- GSE/KSC INTERFACE
- FLIGHT ENVIRONMENT
- ASTRONAUT INTERFACE
- LUNAR ENVIRONMENT
- DATA TRANSMISSION AND RECEPTION
- GENERAL DESIGN CRITERIA

EASEP IN LUNAR MODULE



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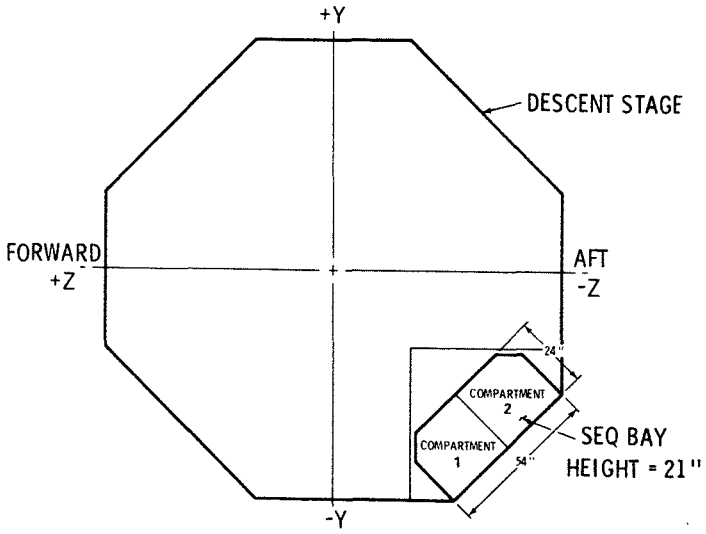
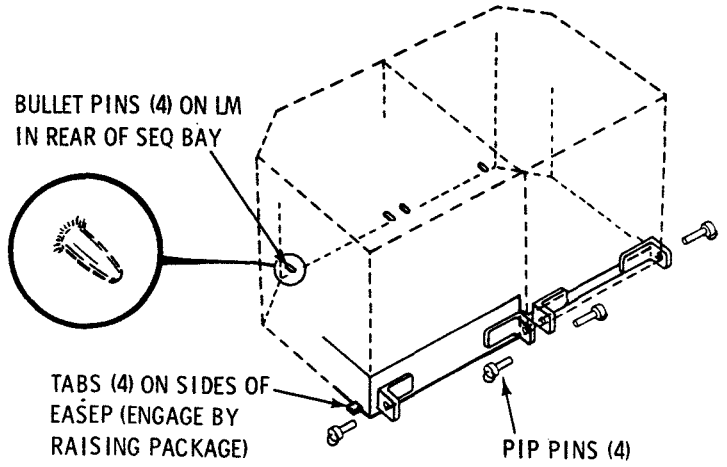
LM INTERFACES





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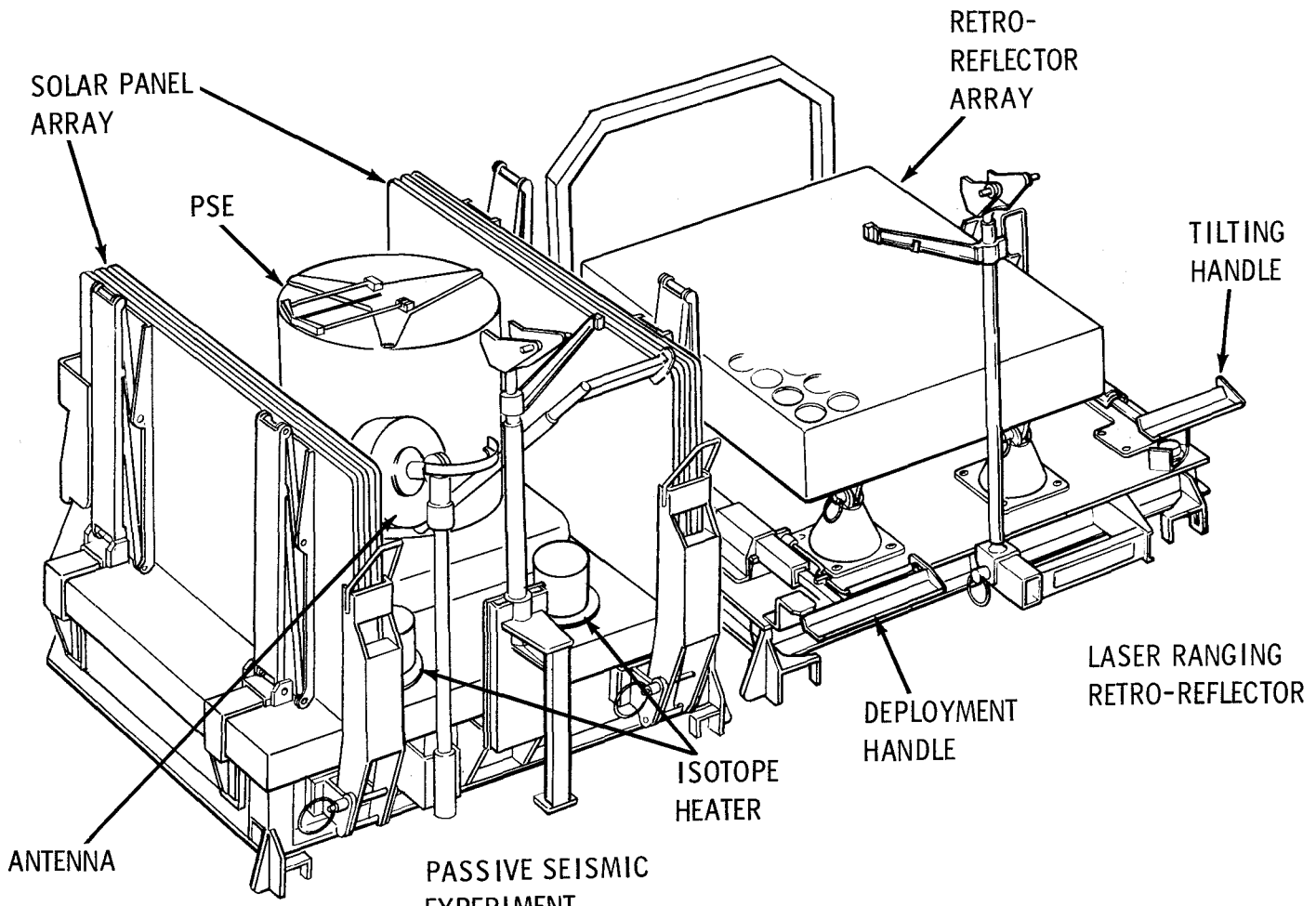
EASEP STOWED CONFIGURATION



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MASS PROPERTIES

RESTRICTIONS

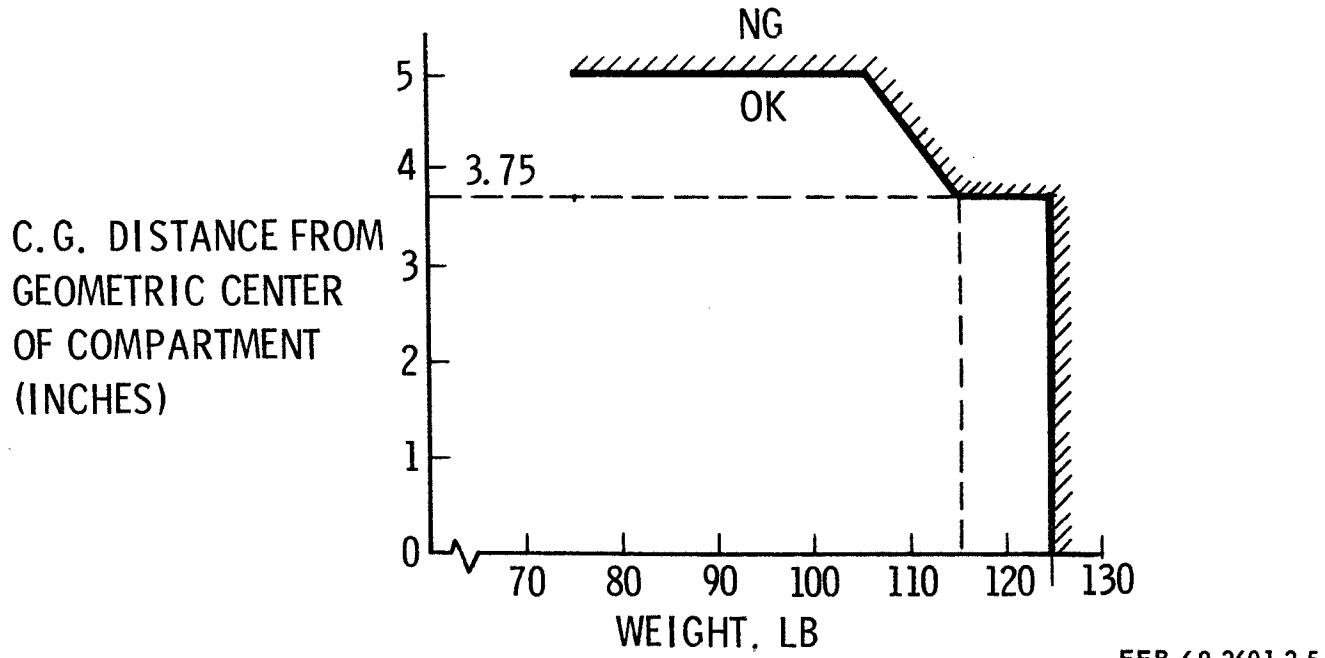
MAX WT IN DESCENT STAGE = 210 LB

LOADING IN EITHER COMPARTMENT:

MAXIMUM WT = 125 LB

EASEP WEIGHTS (LB)

PSEP	105
LRRR	65



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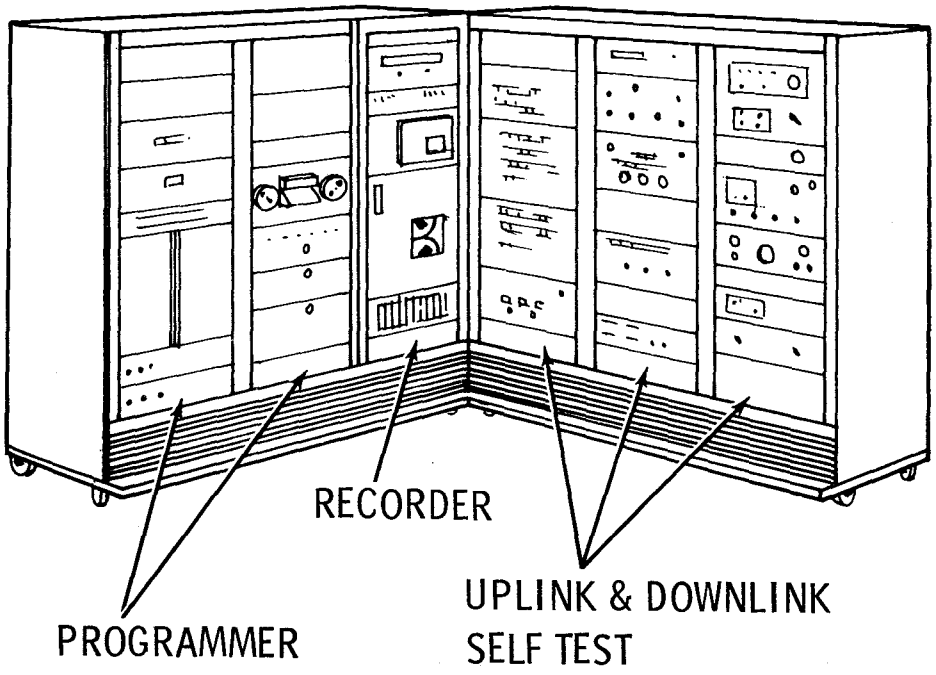
GROUND SUPPORT EQUIPMENT

SYSTEM TEST SET

PROVIDES COMPLETE UPLINK, DOWNLINK & CHECKOUT FUNCTIONS PSEP SYSTEM TEST (MAY BE USED DURING MSFN TEST)



MECH. HANDLING EQUIP.

SHIPPING CONTAINERS
DOLLIES
SLINGS
FIXTURES

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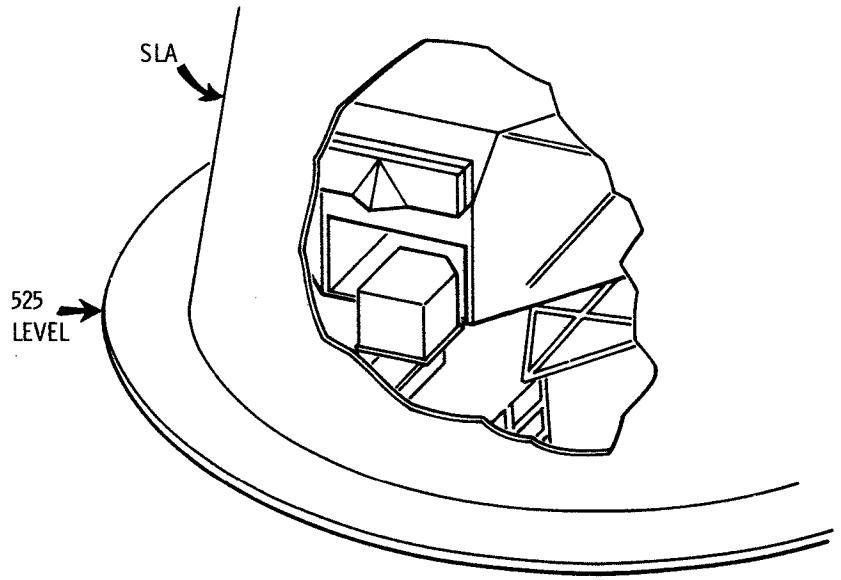
KSC INTERFACE

- PSEP SYSTEM TEST AT BENDIX
- EASEP PREFLIGHT PREPARATIONS AT KSC
  (MAY INCLUDE MSFN COMPATIBILITY TEST)
- EASEP INSTALLATION IN LM
  (AFTER S/C STACKING)



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FLIGHT ENVIRONMENT
(STOWED IN SEQ BAY)

- PSEP INACTIVE (NO ELECTRICAL INTERFACE)
- LAUNCH SHOCK & VIBRATION (TYPICAL SPACECRAFT ENVIRONMENTS)
- SEA LEVEL PRESSURE TO SPACE VACUUM
- TEMPERATURE CONTROLLED BY LM: 0°F TO 160°F (MAXIMUM VALUE OCCURS POST - TOUCHDOWN)
- TOUCHDOWN DYNAMIC LOADS: 8g FOR 10 - 20 MS (ANY AXIS) PLUS 14 RAD/SEC^2 ROTATION ACCEL (AROUND LATERAL AXIS)

ASTRONAUT INTERFACE

SAFETY

BIOMED: WITHIN EXERTION AND LIFE SUPPORT LIMITATIONS

TEMPERATURES: NO CONTACT WITH EXTREMELY HOT SURFACES

PUNCTURES: NO SHARP EDGES, ETC.; NO HAZARDOUS PYROTECHNICS

CAPABILITY

MOBILITY: LIMITATIONS ON REACH (UP & DOWN) KNEELING, TWISTING, ETC.

DEXTERITY: HANDLE SIZE COMPATIBLE WITH GLOVES, NO ADJUSTMENTS REQUIRING EXTREME PRECISION

VISUAL: HIGH-CONTRAST INDICATORS FOR LEVELING AND ALIGNMENT

ASTRONAUT REACH CONSTRAINTS

72" MAXIMUM REACH HEIGHT

66" MAXIMUM WORKING HEIGHT

48"

OPTIMUM WORKING HEIGHT

30"

28" MINIMUM WORKING HEIGHT

22" MINIMUM REACH HEIGHT

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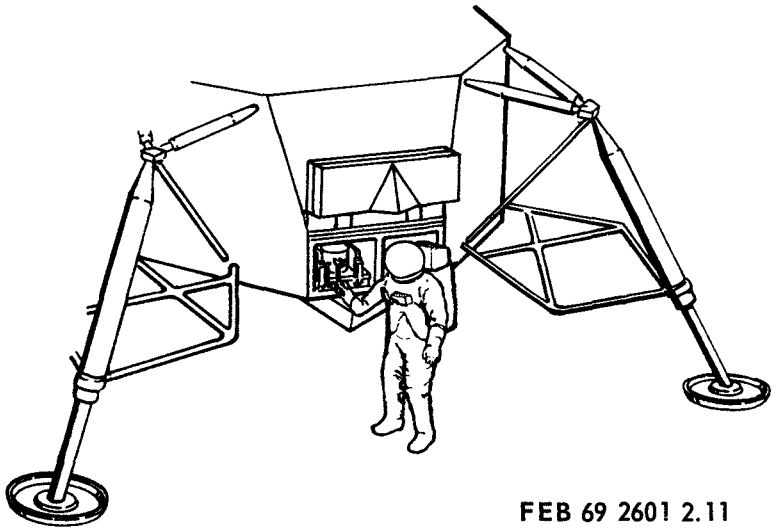
REMOVAL FROM LUNAR MODULE

- BOTTOM OF SEQ BAY 18 IN. TO 60 IN. FROM SURFACE & ± 15° TILT (ANY DIRECTION)
- LM THERMAL DOOR MUST BE CLOSED FOR THERMAL INTEGRITY OF DESCENT STAGE
- LANDING LOCATION WITHIN ± 5° FROM EQUATOR & ± 45° E-W
- LM PROBABLY LANDS FACING NW OR SW
- SUN ANGLE 7° TO 20° (POSSIBLE 45°) ABOVE HORIZON AND RISING



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LUNAR ENVIRONMENT

(SPECIFICATION LED 520 - 1F)

SURFACE TEMPERATURE: - 300° F TO +250° F

SURFACE SLOPES: LESS THAN 12° "EFFECTIVE" SLOPE OVER SPACING OF LM LANDING GEAR (SELECTED SITES).

BEARING STRENGTH: COMBINATION OF SOFT (1 PSI PENETRATES 4 IN) & HARD (INFINITELY RIGID ROCK)

FRICTION COEFFICIENT: 0.4 to 1.0

OPTICAL PROPERTIES: LUNAR NORMAL ALBEDO (0.047 OVER SOLAR SPECTRUM, 0.098 OVER VISIBLE SPECTRUM) PLUS UNIQUE DIRECTIONAL REFLECTIVITY

PRESSURE: LESS THAN 10^{-12} TORR.

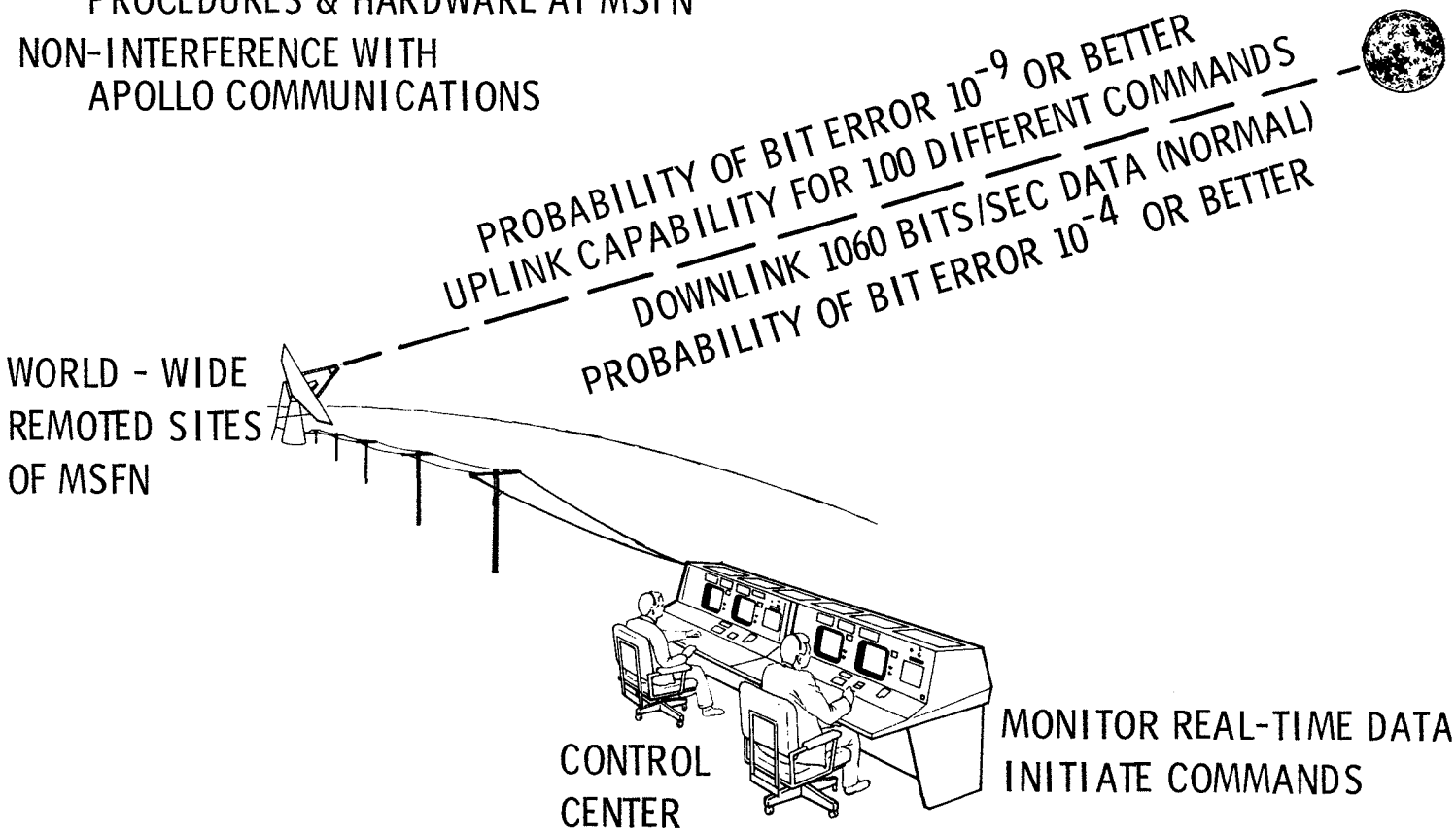
MICROMETEORITES: MSC DOCUMENT DS-21 APPLIES

RADIATION: NEGLIGIBLE EFFECT ON SYSTEM ELECTRONICS FOR ONE-YEAR OPERATION

DATA TRANSMISSION AND RECEPTION

MAXIMUM COMPATIBILITY WITH APOLLO
PROCEDURES & HARDWARE AT MSFN

NON-INTERFERENCE WITH
APOLLO COMMUNICATIONS



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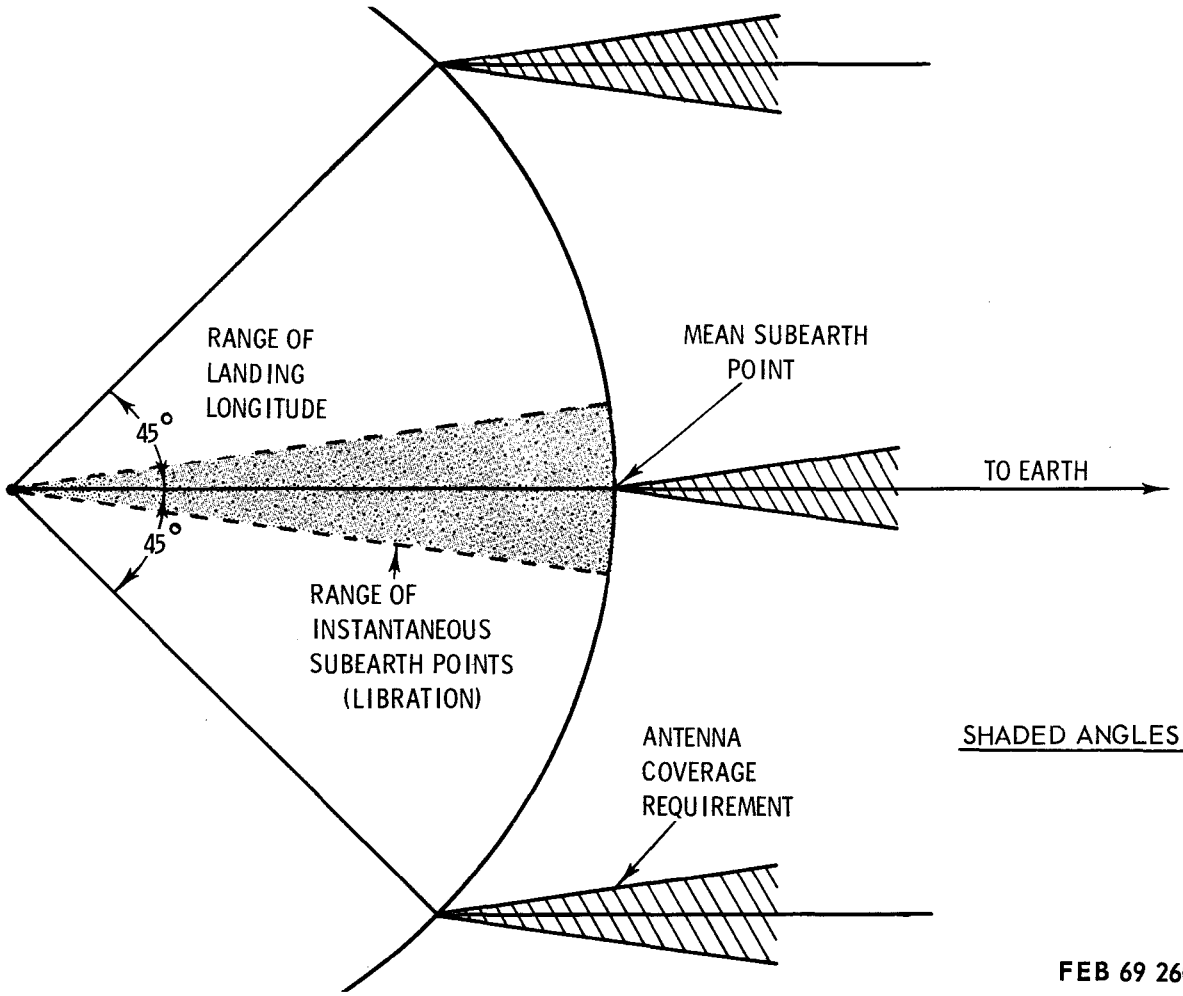
ANTENNA POINTING REQUIREMENT



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LUNAR LIBERATION EFFECT

LUNAR LIBRATION: AN APPARENT WOBBLING MOTION AS VIEWED FROM THE EARTH; CAUSES EQUIVALENT EARTH MOTION IN LUNAR COORDINATES

PRINCIPAL EFFECTS:

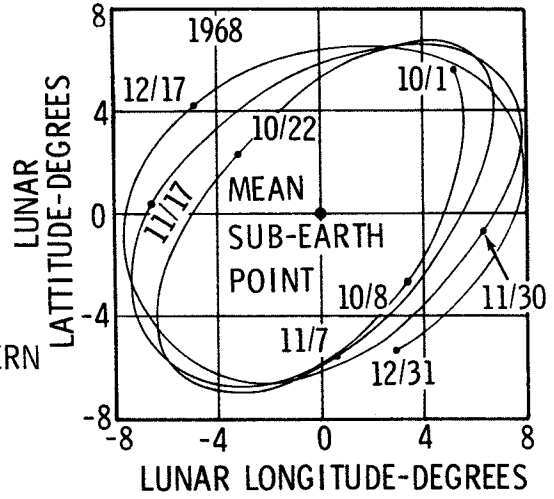
± 7.5° LUNAR LONGITUDE DUE TO:
- CONSTANT ANGULAR RATE OF MOON ABOUT ITS AXIS
- VARIABLE ANGULAR RATE IN ELLIPTICAL ORBIT AROUND EARTH

± 6.5° LUNAR LATTITUDE DUE TO:
- INCLINATION OF MOON'S ROTATION AXIS TO ITS ORBITAL PLANE

SECONDARY EFFECTS:
- NON SPHERICAL EARTH & MOON
- SOLAR PETURBATIONS
- GYROSCOPE & PENDULUM COUPLING

COMBINED EFFECTS: PATTERN CHANGES MONTHLY & YEARLY

EASEP ANTENNA: 22° BEAM WIDTH DOWN 4.2 db AIMED AT MEAN CENTER OF PATTERN



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PSEP/MSFN INTERFACE

<table>
<tr><th>REQUIREMENT</th><th colspan="2">RESOLUTION</th></tr>
<tr><td>APOLLO COMPATIBILITY</td><td colspan="2">S-BAND EQUIPMENT, ESSENTIALLY SAME AS APOLLO;
SCHEDULE SEPARATE MSFN SITES FOR APOLLO & PSEP</td></tr>
<tr><td>3 ALSEP'S SIMULTANEOUSLY</td><td><u>UPLINK</u>
ONE FREQ (2119 MHz) BUT UNIQUE COMMAND ADDRESS IS FOR UP TO 4 ALSEPS</td><td><u>DOWNLINK</u>
USE DUAL SITES; THREE XMTR FREQUENCIES (2276.5, 2278.5 & 2275.5 MHz)</td></tr>
<tr><td>BIT ERROR RATE</td><td>UPLINK (2119 MHz)
<u>10^{-9}</u>: 10 KW XMTR POWER & 15 db PSEP ANTENNA
<table><tr><td>MSFN</td><td>30 - ft</td><td>85 - ft</td></tr><tr><td>S/N MARGIN</td><td>+28 db</td><td>+35 db</td></tr></table>NOTE: XMTR TUNING FOR MAX POWER IS NOT CRITICAL (ASSUMED 30-MIN TURN-AROUND APOLLO TO PSEP)</td><td>DOWNLINK (2276.5 MHz)
<u>10^{-4}</u>: 1 WATT MIN XMTR POWER & 15 db PSEP ANTENNA
NORMAL BIT RATE = 1.06 KBPS
LOW BIT RATE = 0.53 KBPS (CONTINGENCY)
<table><tr><td>MSFN</td><td>30-ft</td><td>85-ft</td></tr><tr><td>S/N MARGIN*</td><td>+7.2 db</td><td>HI</td></tr></table>*FOR 1.06 KBPS</td></tr>
<tr><td>2 - YEAR TIMER</td><td></td><td>BULOVA ACCUTRON
720 ± 30 DAYS</td></tr>
</table>

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PSEP COMMUNICATIONS FEATURES

UPLINK

- PSEP DEPENDS ON ACTIVE USE OF MANY COMMANDS
- 100 POSSIBLE COMMANDS BUT PSEP USES 33
- ONLY 3 COMMANDS REQUIRE PRECISE TIMING (± 10 SEC); PSE FORCED LEVELING
- PSEP RECEPTION & IDENTIFICATION OF COMMANDS IS VERIFIED VIA TM
- PSEP RECEPTION & IDENTIFICATION OF COMMANDS IS VERIFIED VIA TM
- UPLINK 1000 BPS, 61 BITS PER COMMAND
- COMMAND RATE NO MORE THAN 1/SEC

DOWNLINK

- NO DATA STORAGE IN PSEP; HENCE, ALL DATA TRANSMITTED IN NEAR REAL TIME & 100% COVERAGE IS DESIRED
- NORMAL MODE (1.06 KBPS) HAS 64 10- BIT WORDS/FRAME ≈0.604 SEC/FRAME
- LOW BIT RATE HAS SAME FORMAT ≈1.208 SEC/FRAME

- START-UP WHILE ASTRONAUT IS ON SURFACE & BEGIN INITIAL CHECKOUT

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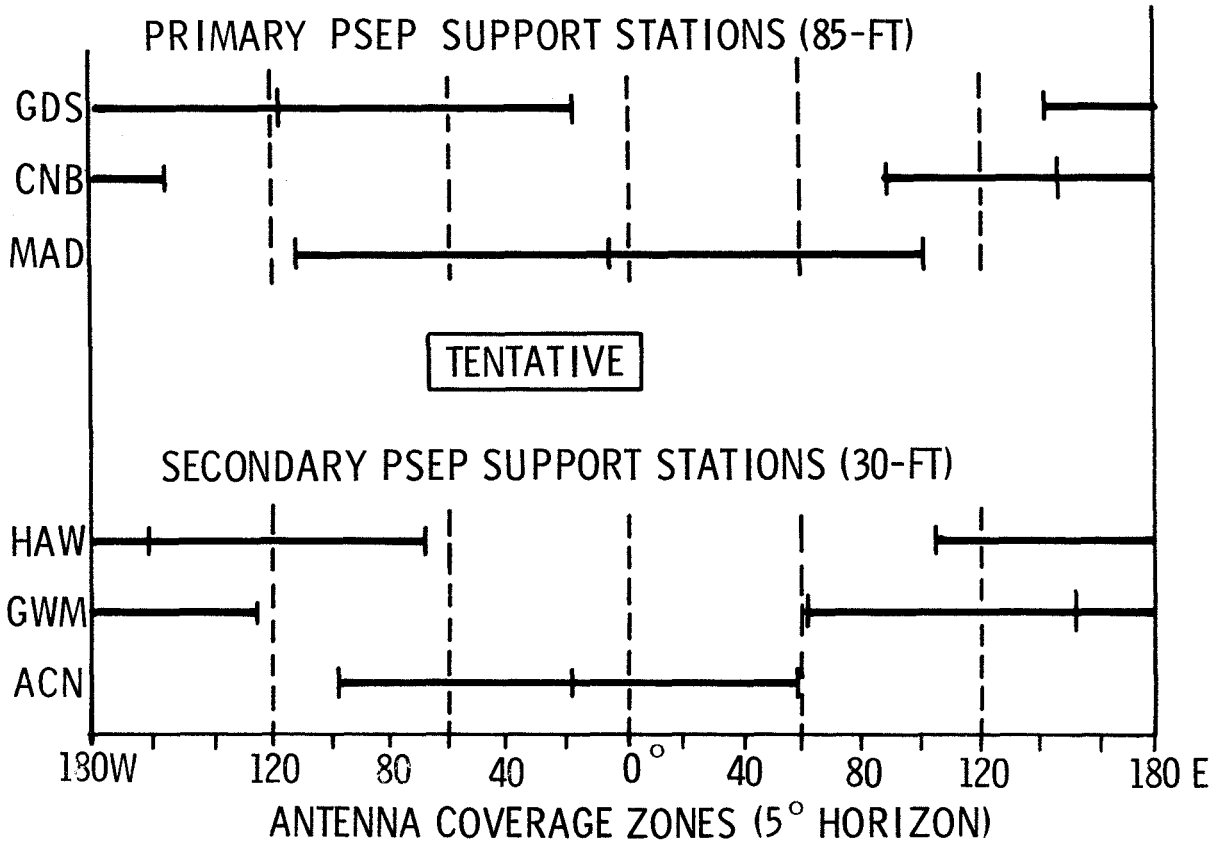
MSFN/MCC SUPPORT REQUIREMENTS

- ALL RECEIVED DATA MUST BE RECORDED BY MSFN
- PSEP MUST BE MONITORED BY MCC FOR FIRST 45 DAYS (i.e., THROUGH SECOND SUNSET) FOR CRITICAL THERMAL TRANSIENTS PLUS SCIENCE (LUNAR DAY ONLY)
- AFTER 45 DAYS, MCC MONITORING FOR 2 CONTINUOUS HR PER 24 REQ'D (2 HR PER 8 HR DESIRED) UNTIL TERMINATION OF OPERATIONS
- POST 60 DAYS MAY OVERLAP ALSEP 1 OPERATIONS

STATION SELECTION FOR PSEP

(MOON DECLINATION MAXIMUM NORTH)



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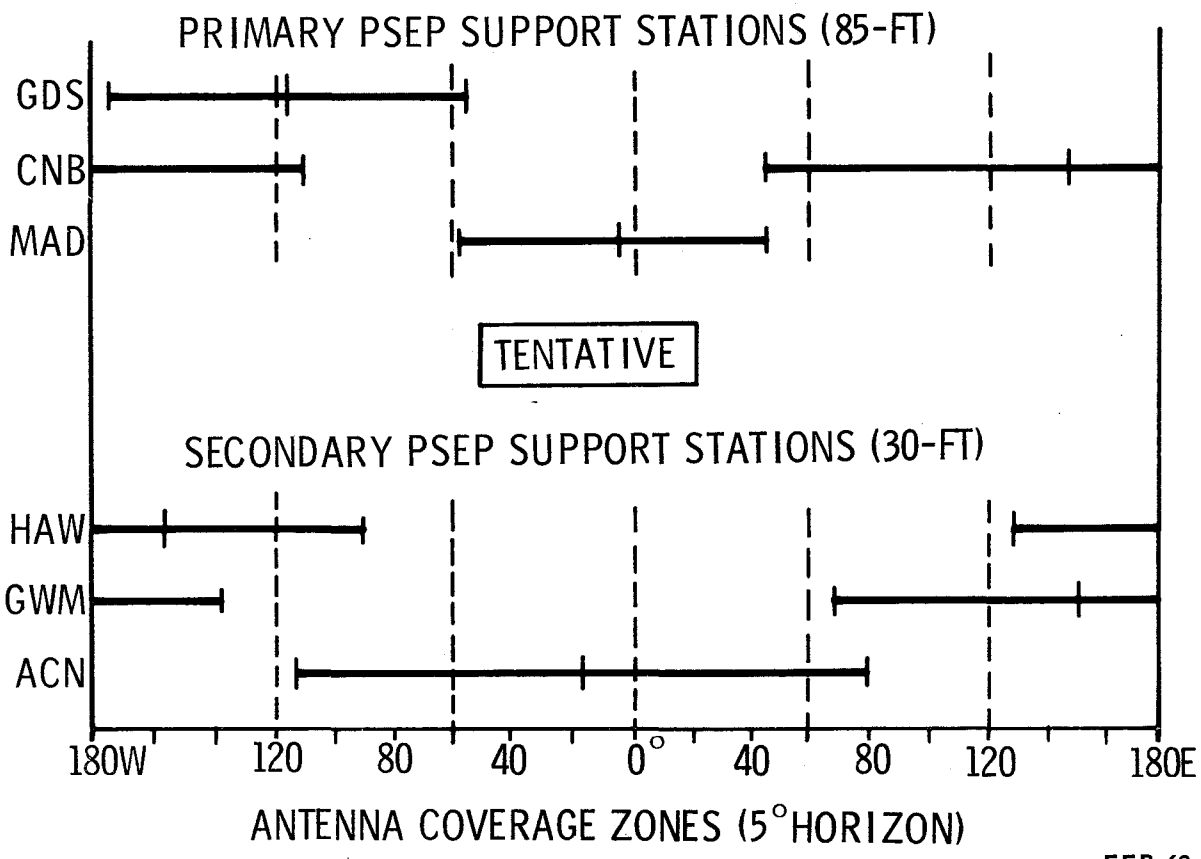
STATION SELECTION FOR PSEP

(MOON DECLINATION MAXIMUM SOUTH)



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GENERAL DESIGN CRITERIA

CREW SAFETY: NO SHARP EDGES, CONTACT WITH HOT SURFACES, EXPOSED HIGH VOLTAGE POINTS, OR HAZARDOUS PYROTECHNICS (USE ONLY ASI)

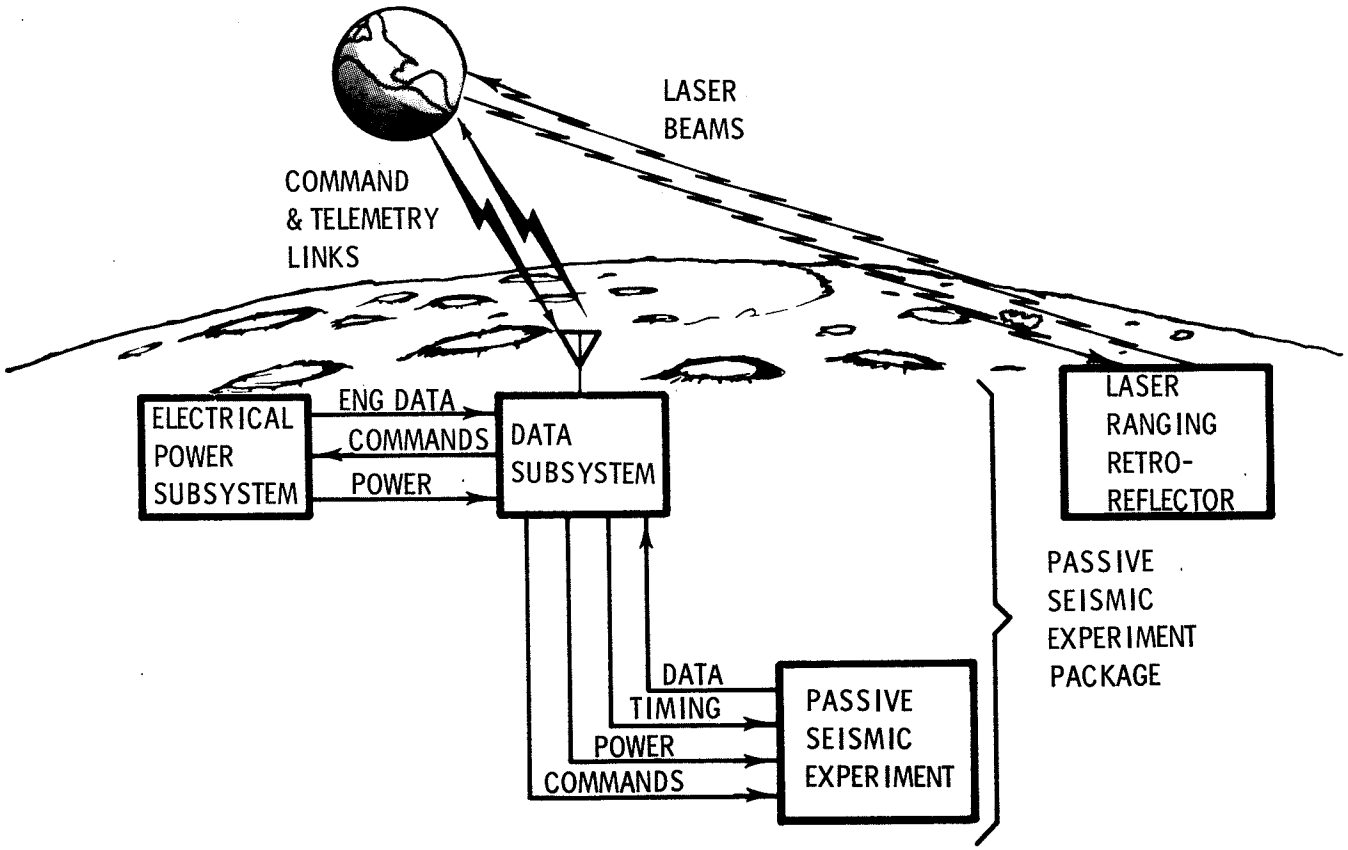
FAIL SAFE: MALFUNCTIONS MUST NOT PROPAGATE SEQUENTIALLY

MATERIALS: WITHOUT NASA APPROVAL, NO FLAMMABLE, TOXIC, OR UNSTABLE MATERIALS & NO PLASTICS EXCEPT EPOXY RESIN-BASED COMPOUNDS, TEFLON, OR MYLAR

EMI: PSEP COMPONENTS SHALL NEITHER BE A SOURCE OF EM DISTURBANCES NOR BE SUSCEPTABLE TO EXTERNAL SOURCES

GROUNDING: SEPARATE POWER & SIGNAL RETURNS; ONE COMMON GROUND POINT IN THE DATA SUBSYSTEM; SHIELDS CONNECTED TO CHASSIS GROUNDS AT BOTH ENDS

EASEP SYSTEM LEVEL DESCRIPTION



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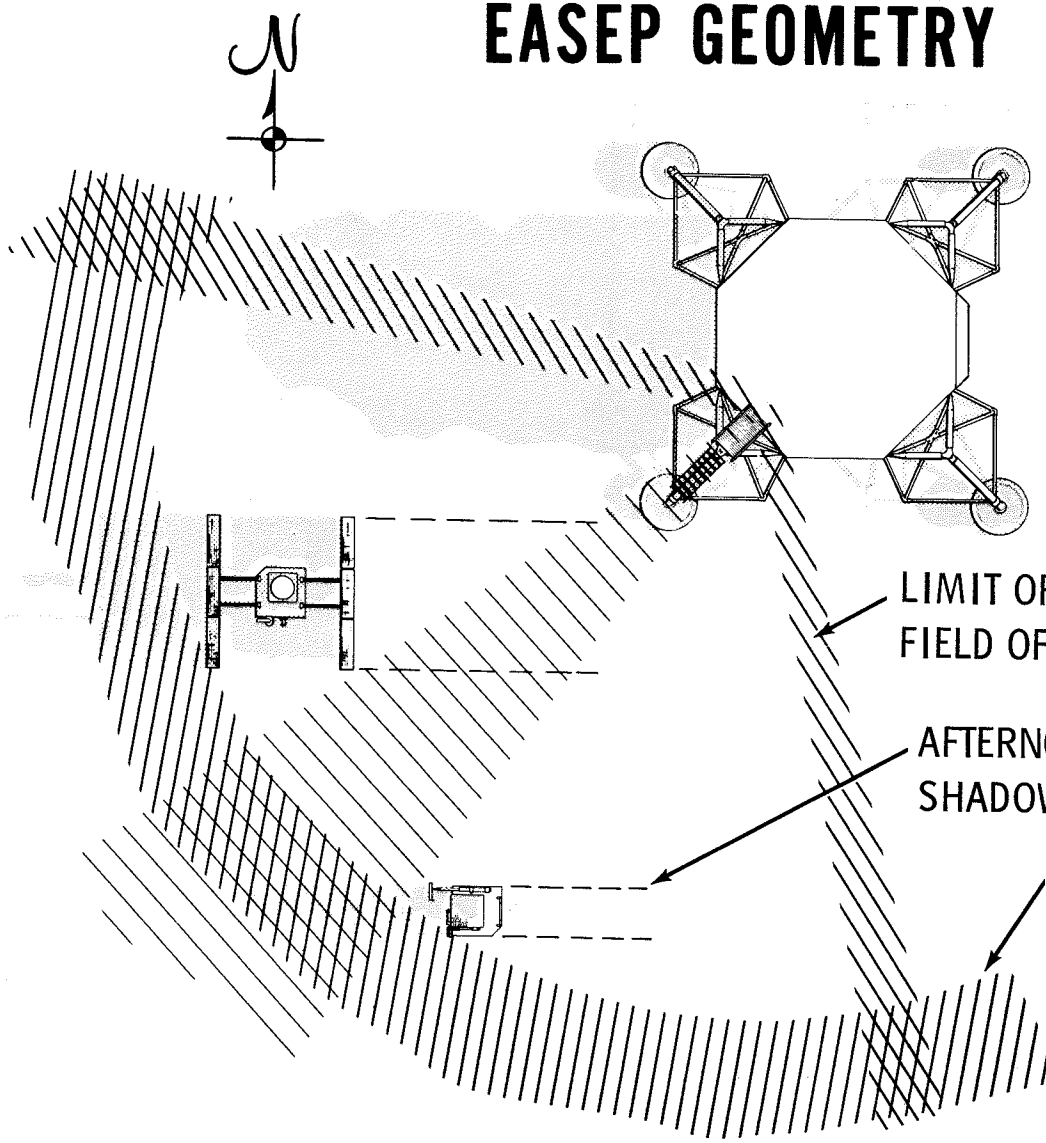
EASEP GEOMETRY



NOTES:

1. SHOWS ONLY ONE SOLUTION TO MANY CONSTRAINTS
2. EXPERIMENTS MUST NOT BE SHADOWED

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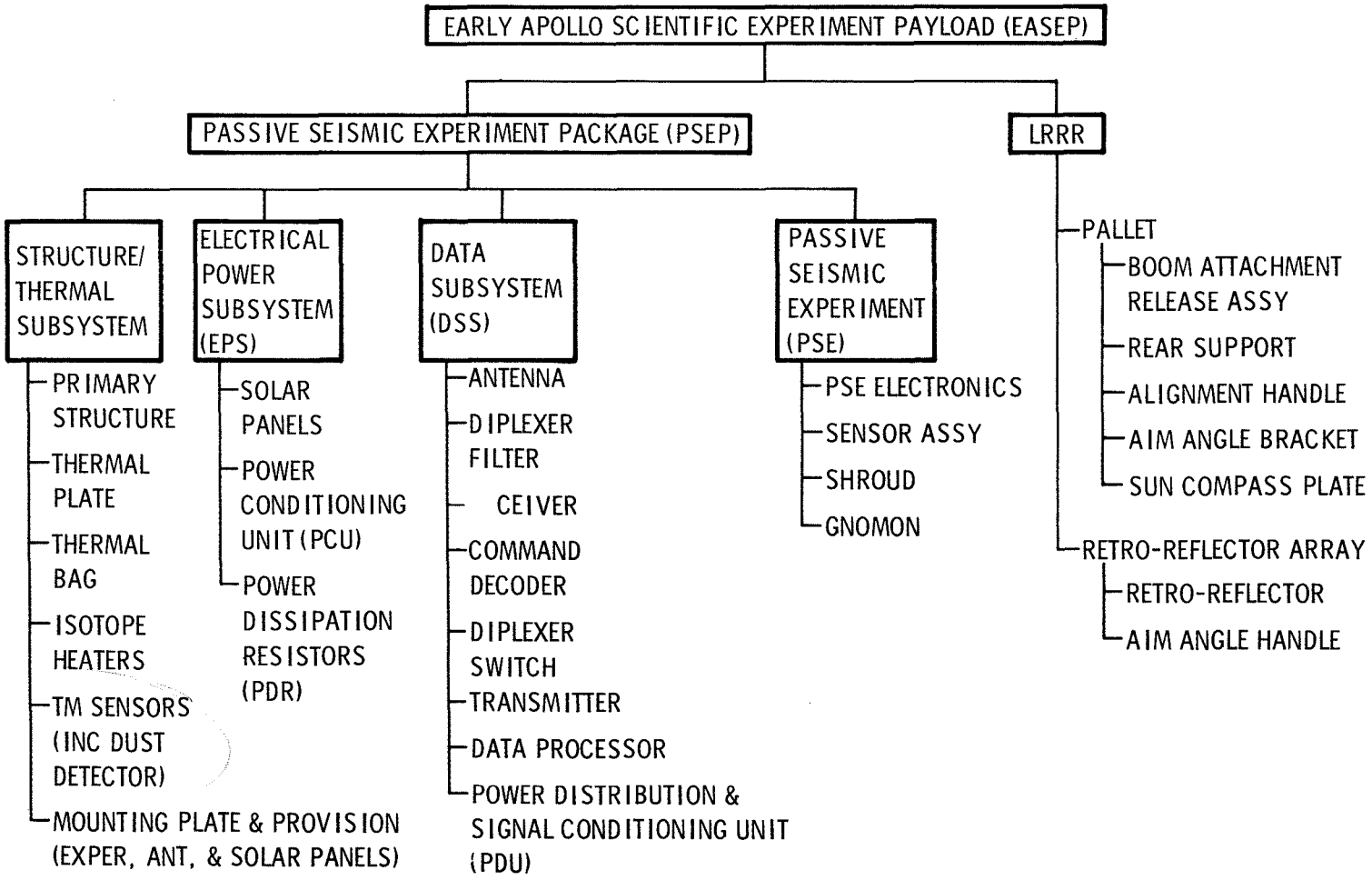
EASEP SYSTEM HARDWARE LIST



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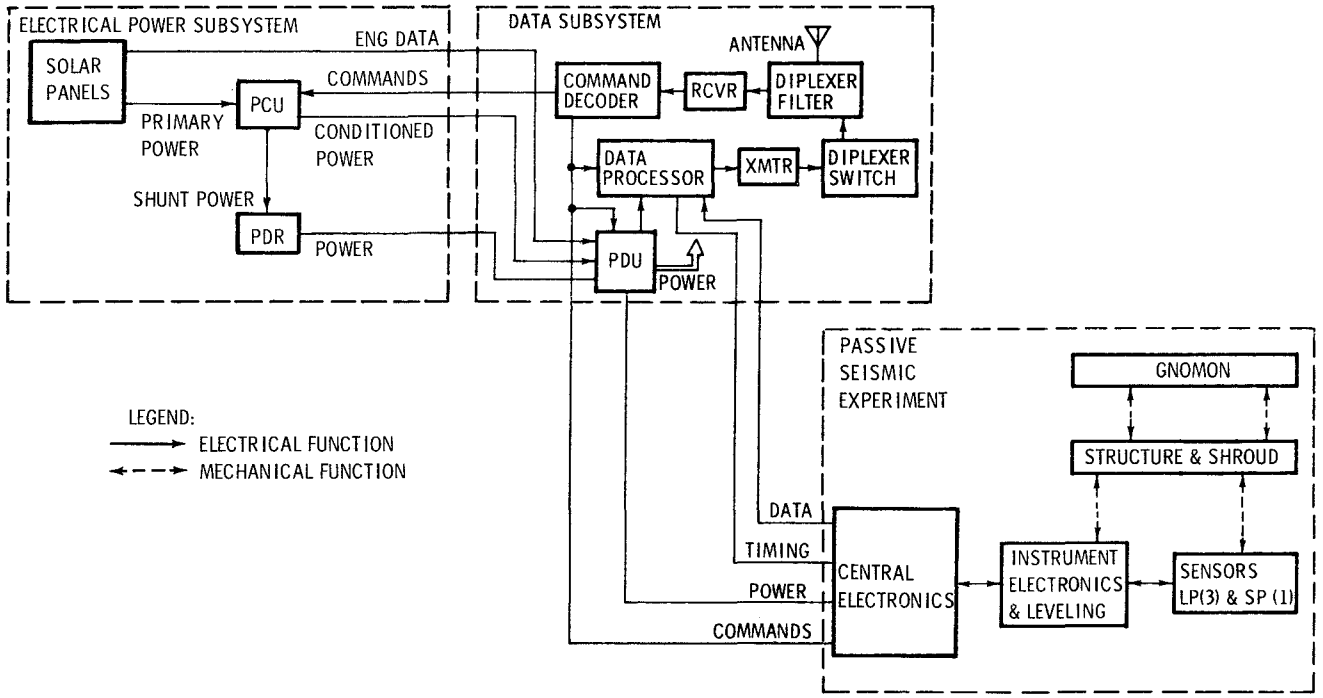
PSEP SYSTEM FUNCTIONAL DIAGRAM



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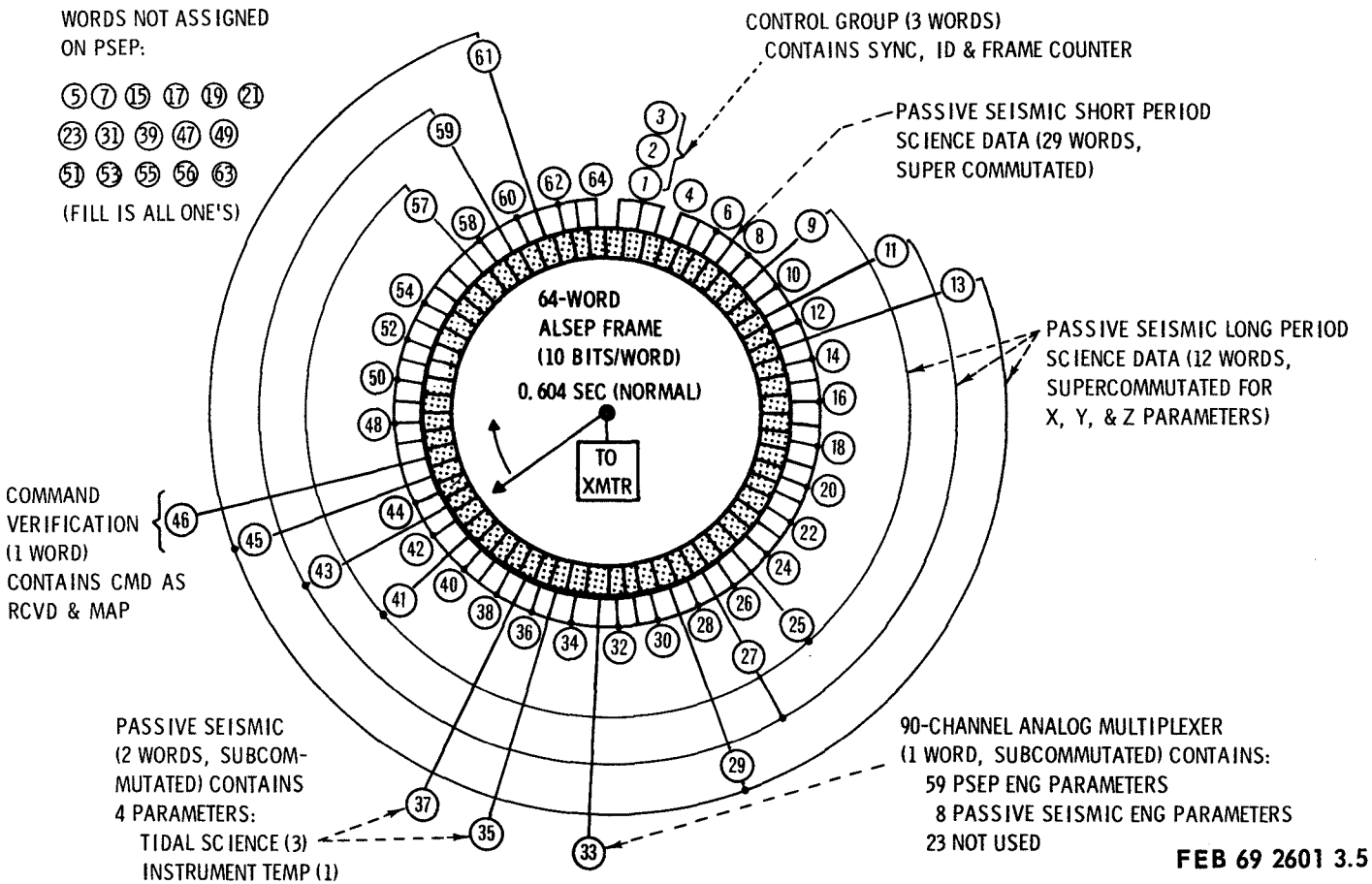
PSEP SYSTEM DATA FLOW



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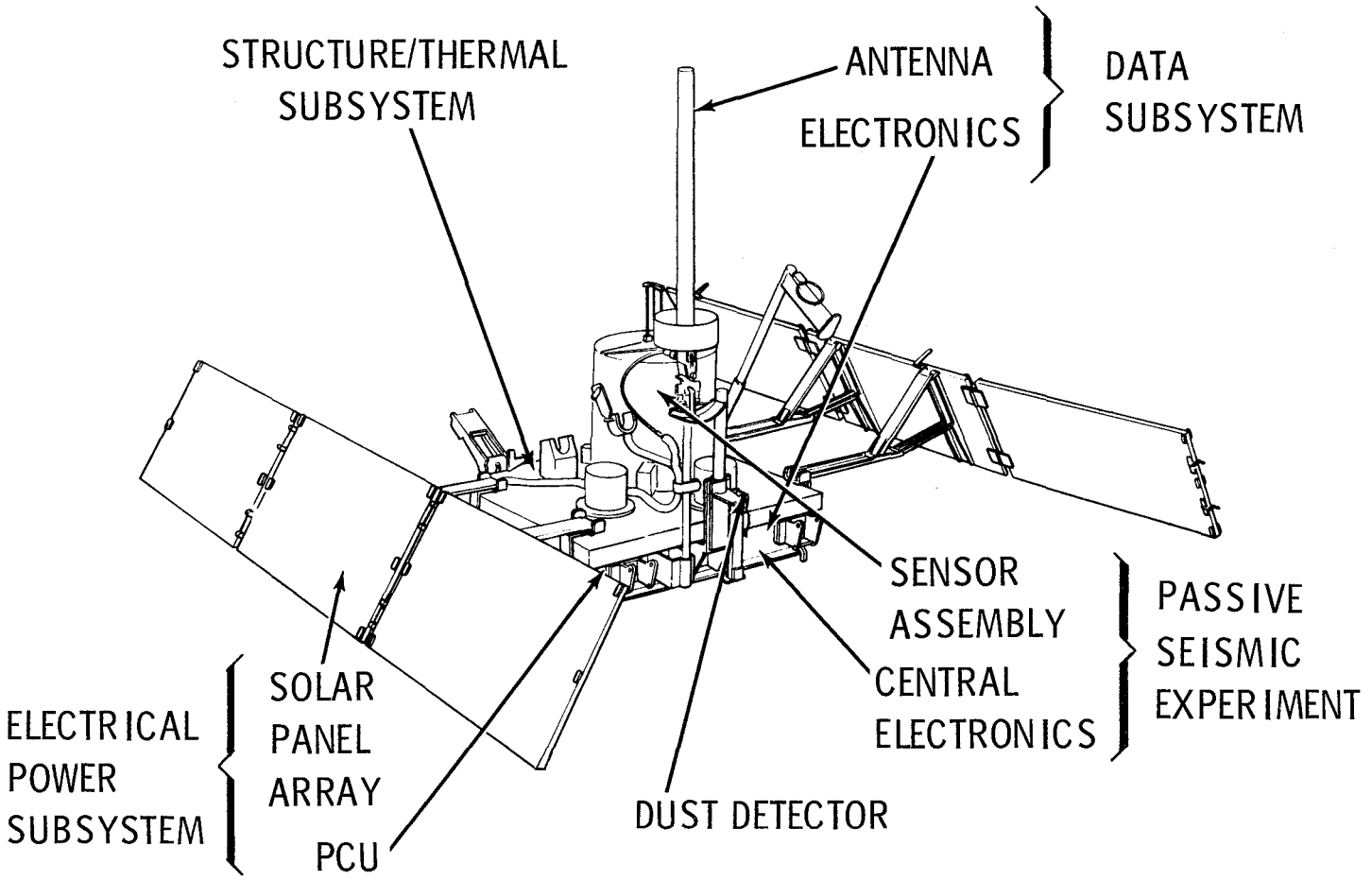
PSEP SUBSYSTEMS



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PSEP STRUCTURE/THERMAL SUBSYSTEM CHARACTERISTICS

COMPONENTS

- PRIMARY STRUCTURE
- BOOM & HANDLE ASSY
- SOLAR PANEL RESTRAINTS & LINKAGE
- ANTENNA POSITIONING MECH
- MOUNTING PLATE
- THERMAL PLATE
- THERMAL BAG
- ISOTOPE HEATERS
- TM INC DUST DETECTOR

PHYSICAL PARAMETERS

SIZE, IN.: VARIOUS
EARTH WT, LB: 34.5 TOTAL
POWER, W: DUST DETECTOR { 0.54 ON / 0.07 OFF

OPERATIONS

DEPLOYMENT (PSEP)

- UNLOAD FROM LM & DETACH FROM BOOM
- TRAVERSE TO DEPLOYMENT SITE
- REMOVE SOLAR PANEL RESTRAINTS
- ROTATE TO UPRIGHT POSITION & ALIGN WRT DHADOW
- UNSTOW ANTENNA & DEPLOY SOLAR PANELS
- ALIGN ANTENNA WRT INDEX PLATE

APPROX TIME, NOT INC TRAVERSE, 5.7 MIN

POST-DEPLOYMENT (STRUCTURE/THERMAL)

- TURN DUST DETECTOR ON PRE-ASCENT

COMMUNICATIONS

COMMANDS
2 FOR DUST DETECTOR (CELLS) ON/OFF

DATA
17 ANALOG ENG PARAMETERS
(INC 6 FOR DUST DETECTOR)
SAMPLED ONCE EACH 54 SEC
PSEP SEQUENCE

KEY FEATURES

- TWO ISOTOPE HEATERS AID IN LUNAR NIGHT SURVIVAL WHEN PSEP IS NOT OPERATING
- CHARACTERISTICS (EACH)
  - PLUTONIUM: 36 GRAMS
  - DOSAGE RATE: 0.62 MILLIREM/HR AT ONE METER
  - THERMAL OUTPUT: 15 WATTS

SECOND SURFACE MIRRORS

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PSEP THERMAL CONTROL

CONTROL TECHNIQUE	CENTRAL ELECTRONICS COMPARTMENT	PASSIVE SEISMIC SENSOR ASSEMBLY
ISOLATE FROM LUNAR SURFACE EFFECTS • RADIATIVE • CONDUCTIVE	THERMAL BAG SPECIAL FITTINGS	SHROUD
ISOLATE FROM SOLAR INPUTS & CONTROL RADIATIVE OUTPUT	SECOND SURFACE MIRROR	SHROUD & SECOND SURFACE MIRROR
PROVIDE AUXILIARY HEAT SOURCES • OPERATIONAL RELIABILITY • SCIENTIFIC STABILITY • SURVIVAL	N/A N/A ISOTOPE HEATERS	N/A ELECTRIC HTR

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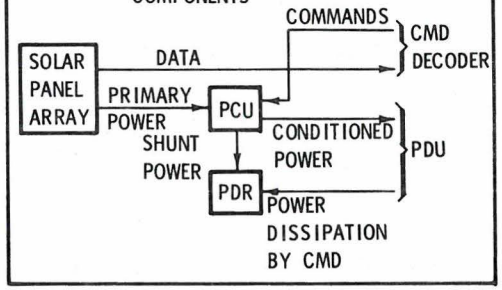
PSEP ELECTRICAL POWER SUBSYSTEM CHARACTERISTICS

COMPONENTS



PHYSICAL PARAMETERS

SIZE, IN.: 24 X 13 (EACH OF 6 PANELS

EARTH WT, LB: 12.2 (TOTAL 6 PANELS)
4.5 (PCU)

PDR CONSISTS OF RESISTORS MOUNTED EXTERNALLY ON PRIMARY STRUCTURE

PERFORMANCE

SOLAR PANEL ARRAY

OUTPUT POWER: 34 TO 46 W
OUTPUT VOLTAGE: 16.2 ± 0.2 VDC

PCU OUTPUT VOLTAGES (VDC)

+ 29, + 15, + 12, + 5, -6, -12

PCU REGULATION

± 1% ON ALL OUTPUTS

COMMUNICATIONS

COMMANDS

2 FOR PCU SELECTION (REDUNDANCY)
4 FOR PDR LOADS (2) ON/OFF

DATA

2 SOLAR PANEL TEMPS
2 SOLAR PANEL OUTPUT (VOLT & AMP)
2 PCU SHUNT AMPS
4 PCU TEMPS
6 OUTPUT VOLTAGES (IN PDU)
SAMPLED ONCE EACH 54-SEC PSEP SEQUENCE

KEY FEATURES

- NO BATTERY; INOPERATIVE DURING LUNAR NIGHT
- EXTERNAL LOADS (PDR) CAN BE SWITCHED ON/OFF BY CMD FOR POWER MANAGEMENT
- PCU HAS REDUNDANT SECTIONS (PCU 1 & PCU 2) SELECTABLE BY CMD
- PCU 1 HAS OUT-OF-TOLERANCE SENSING ON +12V LINE. SWITCHES AUTOMATICALLY TO PCU 2 BEYOND 11 & 13V. PCU 2 HAS NO SWITCHBACK PROVISION & MAY OPERATE OUT OF TOLERANCE.

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CIRCUIT AND SYSTEM PROTECTION

- ACCOMPLISHED MAINLY BY PDU
- MINOR OVERLOADS
  - ACCEPTED UNTIL TOTAL POWER DEMAND BECOMES EXCESSIVE
  - SENSED AS DECREASE IN PCU SHUNT AMPS (APPROACHING ZERO)
  - "RIPPLE OFF" CIRCUIT SWITCHES PSE FROM OPER TO STBY
  - CAN BE SWITCHED BACK (OPER) ONLY BY CMD
- MAJOR OVERLOADS
  - 0.50 ± 0.05 AMP CIRCUIT BREAKER IN PSE ± 29V OPER LINE SWITCHES TO STBY
  - +29V LINE OF XMTR HAS 0.70 ± 0.14 AMP CIRCUIT BREAKER
  - +12V LINES OF XMTR & RCVR HAVE 0.110 TO 0.225 AMP CIRCUIT BREAKERS
  - PSE +29V STBY (HTR) LINE HAS 0.50 AMP FUSE
  - DUST DETECTOR +12V & -12V LINES HAVE 0.25 AMP FUSES
- AUTOMATIC RESET
  - TIMER ATTEMPTS RCVR RESET EVERY 12 HR

EASEP/ASTRONAUT INTERFACE

	CONSTRAINT	RESOLUTION
SAFETY	BIOMEDICAL	SIMPLE TASKS REQUIRING MINIMAL EFFORT AND TIME DOSAGE RATE OF ISOTOPE HEATER NON-HAZARDOUS
	THERMAL	NO SIGNIFICANT THERMAL EXPOSURES
	SUIT PUNCTURE	NO SHARP EDGES; PSE UNCAGE USES APPROVED PYROTECHNIC
CAPABILITY	MOBILITY	NO EXCESSIVE REACH - NO KNEELING
	DEXTERITY	ALL MECHANISMS ACTUATED BY PULL PINS, HANDLES OR LANYARDS
	VISUAL	LEVEL/ALIGN INDICATORS COMPATIBLE WITH VISOR LIMITATIONS

REMOVE LRRR AND PSEP FROM LM, TRAVERSE TO DEPLOYMENT SITE, DEPLOY LRRR AND PSEP; TOTAL TIME APPROX 10 MIN

EASEP WEIGHT SUMMARY

PSEP		LRRR	
STRUCTURE/THERMAL SUBSYSTEM & ELECTRONICS	56.66	LRRR ARRAY	32.83
SOLAR PANELS & ASSEMBLY	17.69	PALLET & STRUCTURE	14.50
ANTENNA & CABLE	2.97	GNOMON, BUBBLE & MISC	1.16
PSE	20.60	REAR SUPPORT	0.76
DUST DETECTOR & CABLE	.35	ALIGNMENT HANDLE	1.80
PDR	.60		
MIRRORS	.22	AIM ANGLE HANDLE	1.25
CABLES & MISC	3.85		
ISOTOPE HEATERS	6.00		
TOTAL	108.94		52.30

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PSEP POWER SUMMARY

ITEM	WATTS	
RECEIVER	0.8	
DECODER	1.2	
DATA PROCESSOR	0.5	
ANALOG MULTIPLEXER	1.4	
POWER DISTRIBUTION UNIT	1.5	
TRANSMITTER	9.0	NOMINAL
PSE		
SENSOR	0.7	
ELECTRONICS	3.7	
DUST DETECTOR	0.3	
PCU CONVERTER	4.7	(VARIES WITH LOAD)
PCU REGULATOR	1.0	(PLUS 3 WATTS INTERMITTANT FOR PSE LEVEL)
	24.8 TOTAL	

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PSEP DATA SUMMARY

NORMAL BIT RATE (1.06 KBPS)		S/T	POWER	DSS	PSE	NOT USED	COMMENTS
CMD	POWER CONTROL	2	4	4	3	9(a)	TOTAL 100
	OTHER OPERATIONS	-	2	7	15	54	
NUMBER OF WORDS	PER PSEP FRAME	-	-	5(b)	43	16	TOTAL 64(b)
	PER EXPER FRAME	-	-	-	86	-	
REP RATE (SEC)	BASIC FRAME	-	-	0.6	1.2	-	
	COMPLETE CYCLE	-	-	54	1.2	-	
NUMBER OF PARAM-ETERS	SCIENCE	-	-	-	7	-	
	HK, IN DIGITAL FORMAT	-	-	6(c)	1	-	
	HK, IN PSEP ADC	17	18	24	8(d)	23	TOTAL 90

(a) MAY BE USED FOR TEST (b) 5 DSS WORDS = ADC OUTPUT PLUS 6 PARAMETERS
(c) SYNC, FRAME CNTR, BIT RT ID, PSEP ID, CMD AS RCVD, CMD MAP
(d) 8 PSE WORDS = 11 PARAMETERS

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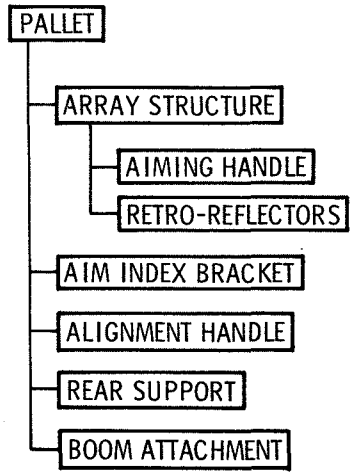
LASER RANGING RETRO-REFLECTOR SYSTEM CHARACTERISTICS

COMPONENTS



PHYSICAL PARAMETERS

SIZE, IN.:
PALLET 26.00 X 27.25
STOWED HEIGHT 17.00
(NOT INC BOOM ATTACHMENT)

EARTH WT, LB: 55

OPERATIONS

DEPLOYMENT

- REMOVE FROM LM
- TRAVERSE TO DEPLOYMENT SITE
- ROUGH ALIGN
- ADJUST TILT
- ROTATE TO UPRIGHT POSITION
- MAKE FINAL ALIGNMENT

APPROX TIME, NOT INC TRAVERSE, 3.5 MIN

POST-DEPLOYMENT

PASSIVE RETRO-REFLECTOR USED IN EXPERIMENTS WITH EARTH-BASED LASER TRANSMITTING/RECEIVING EQUIPMENT

KEY FEATURES

100 OPTICAL REFLECTORS IN ARRAY
EACH 1.5-IN. DIAMETER CUBE CORNER

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EASEP OPERATIONS

PRELAUNCH PHASE: FROM ARRIVAL OF EASEP AT KSC TO COMPLETION OF INSTALLATION IN LAUNCH VEHICLE

LUNAR SURFACE PHASE: CREW ACTIVITIES WHILE DEPLOYING EASEP ON LUNAR SURFACE

PSEP INITIAL CHECKOUT MISSION PHASE: START-UP ACTIVITIES AT MCC FROM FIRST COMMAND (XMTR ON) TO COMPLETION OF INITIAL PSEP CHECKOUT, READY FOR NORMAL OPERATION (OVERLAPS APOLLO LUNAR MISSION)

PSEP FORTY-FIVE DAY MISSION PHASE: FROM COMPLETION OF INTIAL PSEP CHECKOUT TO END OF 45TH DAY AFTER DEPLOYMENT; MSFN/MCC OPERATES CONTINUOUSLY DURING PSEP PERIODS OF ACTIVITY (LUNAR DAY)

PSEP ONE-YEAR MISSION PHASE: FROM COMPLETION OF 45TH DAY AFTER DEPLOYMENT TO TERMINATION OF OPERATIONS (UP TO ONE YEAR AFTER DEPLOYMENT); MSFN/MCC OPERATES INTERMITTENTLY DURING PSEP PERIODS OF ACTIVITY (LUNAR DAY) FOR APPROX 2 HR OUT OF EVERY 24 HR.

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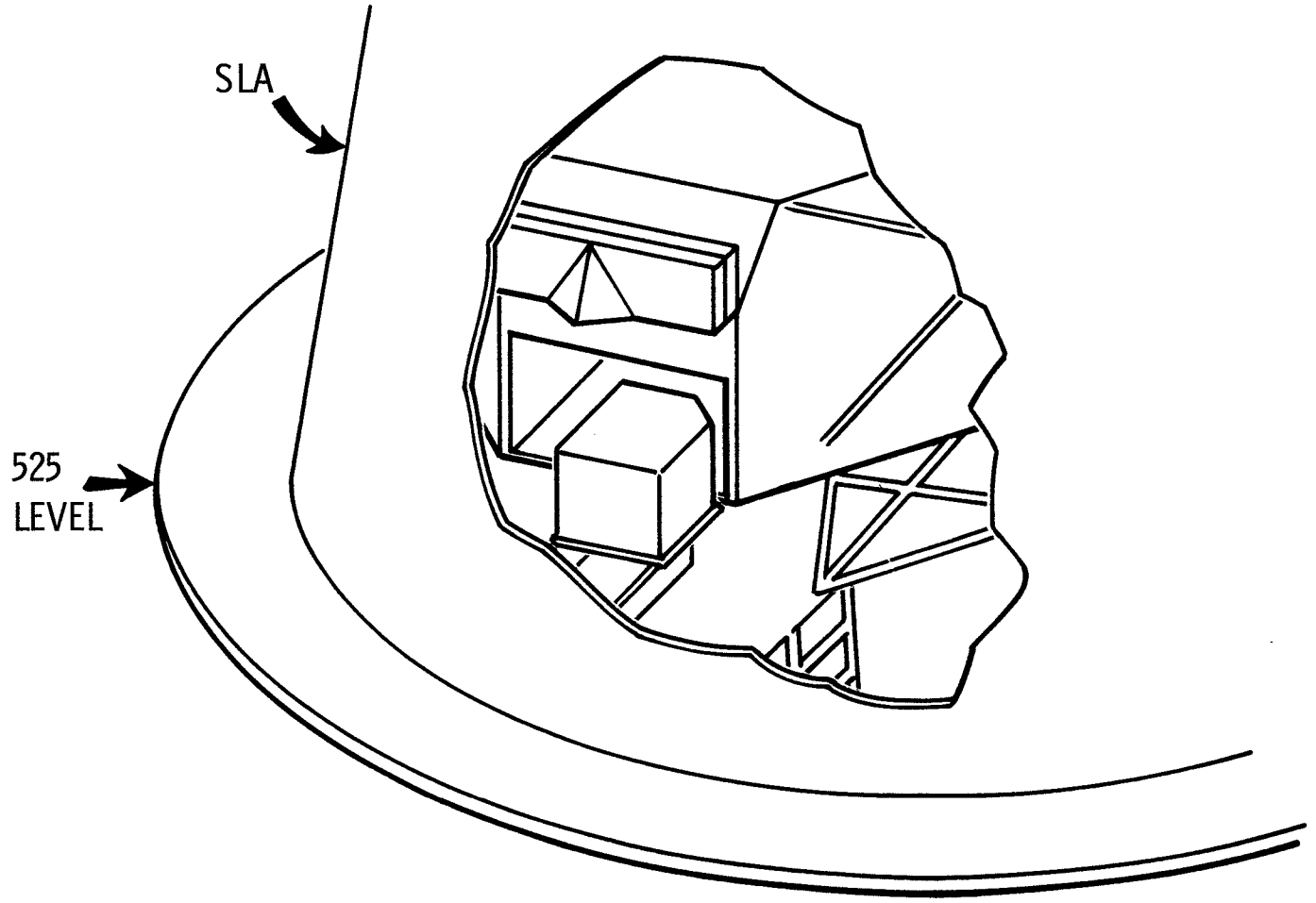
PRELAUNCH PHASE

- PREPARATIONS FOR FLIGHT
  - PSE PRESSURE CHECK
  - PREFLIGHT REVERIFICATION OF ORDNANCE
  - PSEP DISASSEMBLY
  - LRRR DISASSEMBLY
  - ISOTOPE HEATER FIT CHECK

  MAY INCLUDE NETWORK COMPATIBILITY TEST

- EASEP INSTALLATION IN LM
  - TRANSPORT PSEP & LRRR TO LAUNCH PAD
  - ASSEMBLE PSEP IN SLA (INC HEATER INSTALLATION)
  - PERFORM PSE PREFLIGHT PREPARATION
  - INSERT PSEP IN LM
  - ASSEMBLE LRRR IN SLA
  - INSERT LRRR IN LM

EASEP INSTALLATION IN LM



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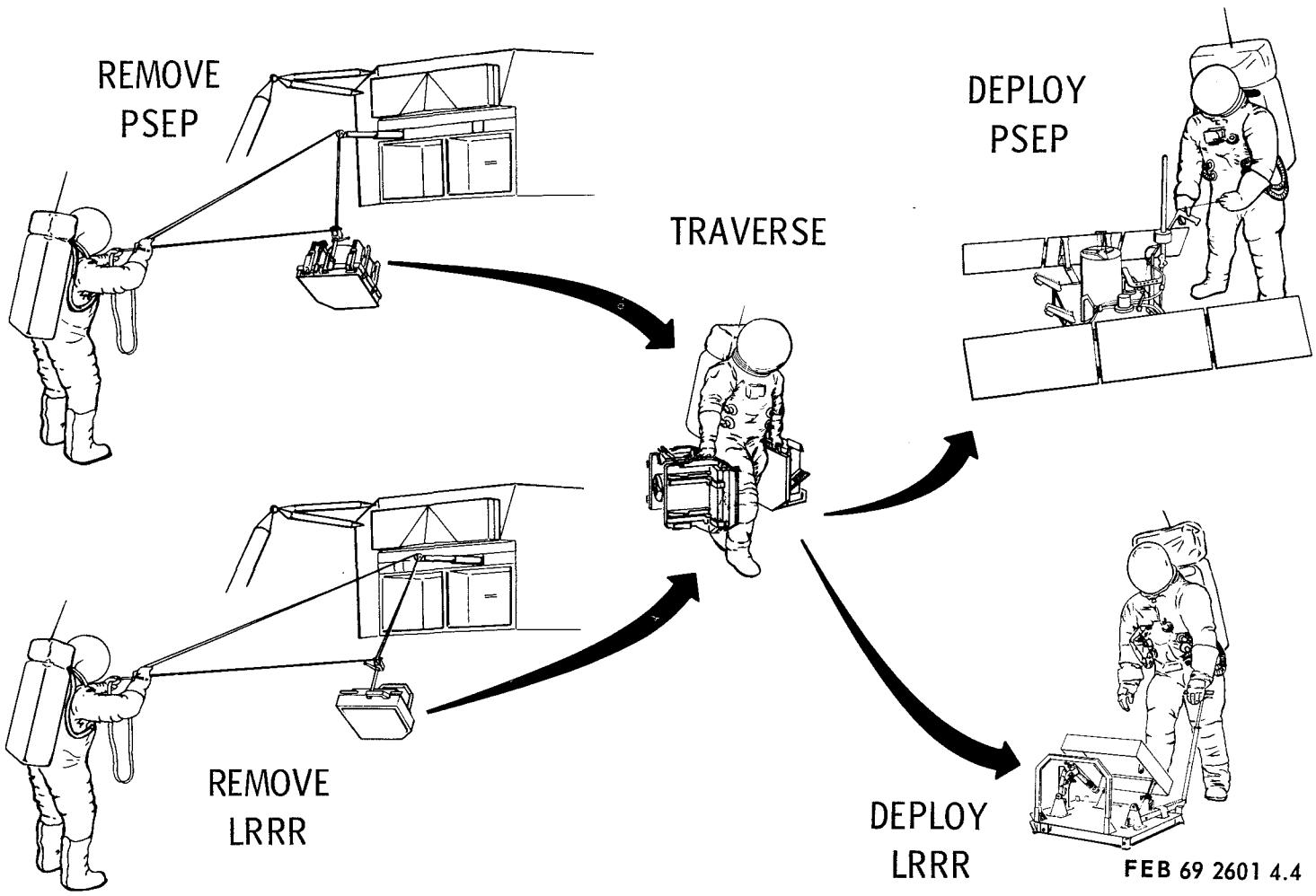
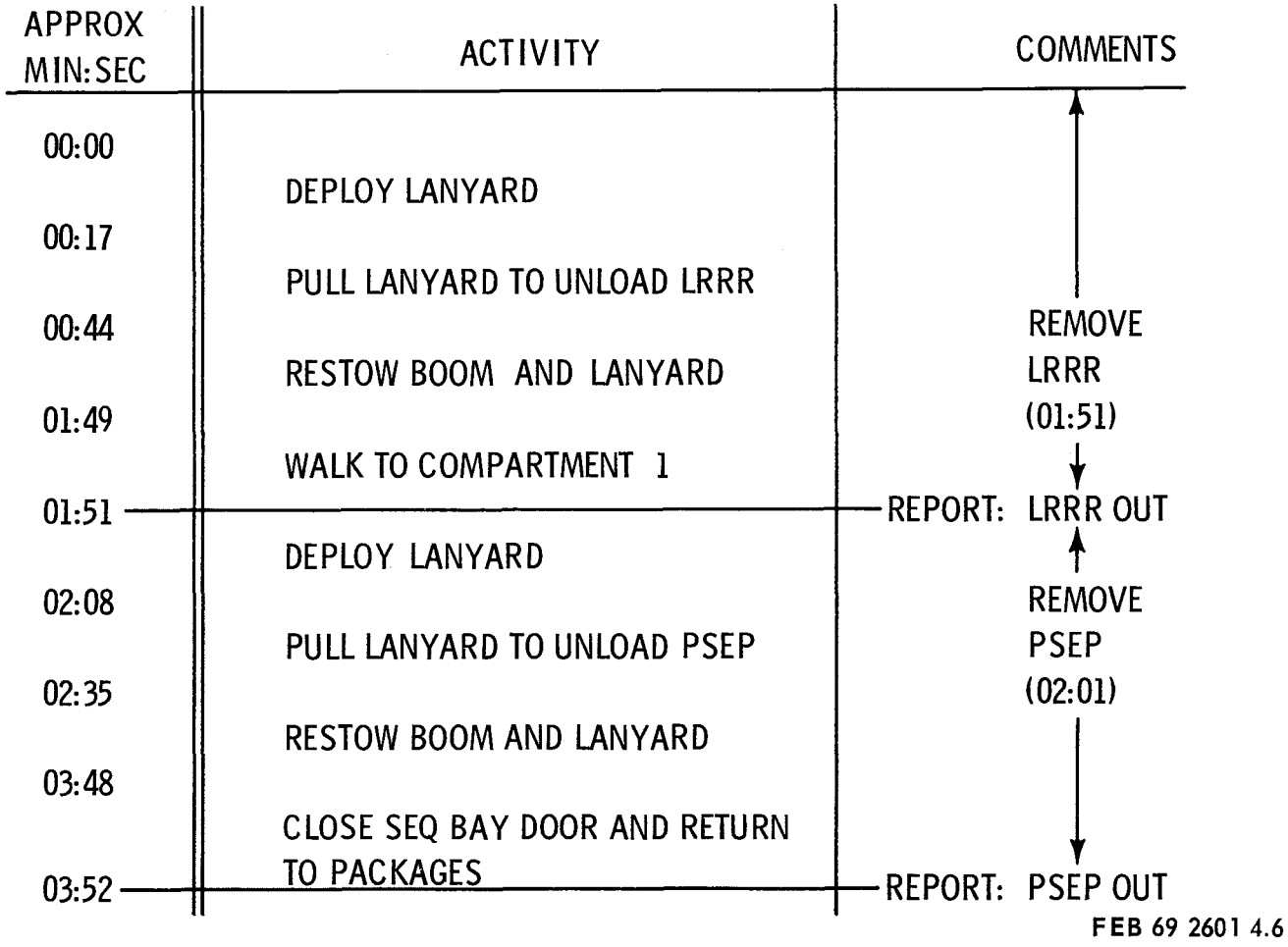
LUNAR SURFACE PHASE



EASEP DEPLOYMENT TIMELINE

- KEY TO MISSION PLANNING
- THIS TIMELINE IS FOR REFERENCE ONLY–THE FINAL TIMELINE WILL CONFORM TO THE FLIGHT PLAN
- EASEP; 1-MAN EVA
- CREW PREPARATION ACTIVITIES NOT INCLUDED
  - DESCENT TO SURFACE
  - PLSS STATUS CHECK
  - EVA COMM CHECK
  - OPENING OF SEQ BAY DOOR

DEPLOYMENT TIMELINE (CONT.)



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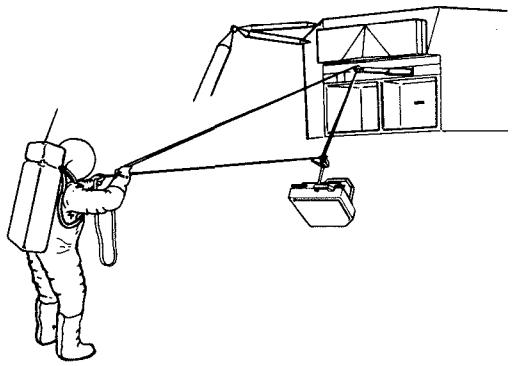
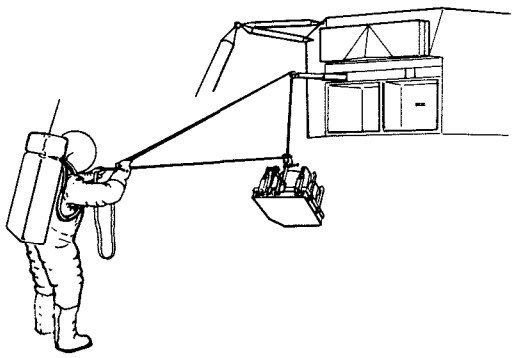
REMOVE LRRR AND PSEP



- TASKS ARE IDENTICAL FOR BOTH LRRR AND PSEP
- DEPLOY LANYARD
  - RETRIEVE LANYARD FROM COMPARTMENT
  - WALK 10 FT FROM LM TRAILING LANYARD
- PULL LANYARD TO UNLOAD PACKAGE

  THIS ACTION RELEASES PACKAGE TIE-DOWNS, EXTENDS BOOM, WITHDRAWS PACKAGE AND LOWERS IT TO LUNAR SURFACE IN A CONTINUOUS MOTION
- RESTOW BOOM AND LANYARD
  - RELEASE LANYARD FROM PACKAGE
  - PULL LANYARD TO RESTOW BOOM
  - RETURN LANYARD TO COMPARTMENT
- WALK TO ADJACENT COMPARTMENT AND REMOVE SECOND PACKAGE
- CLOSE SEQ BAY DOOR AND RETURN TO PACKAGES



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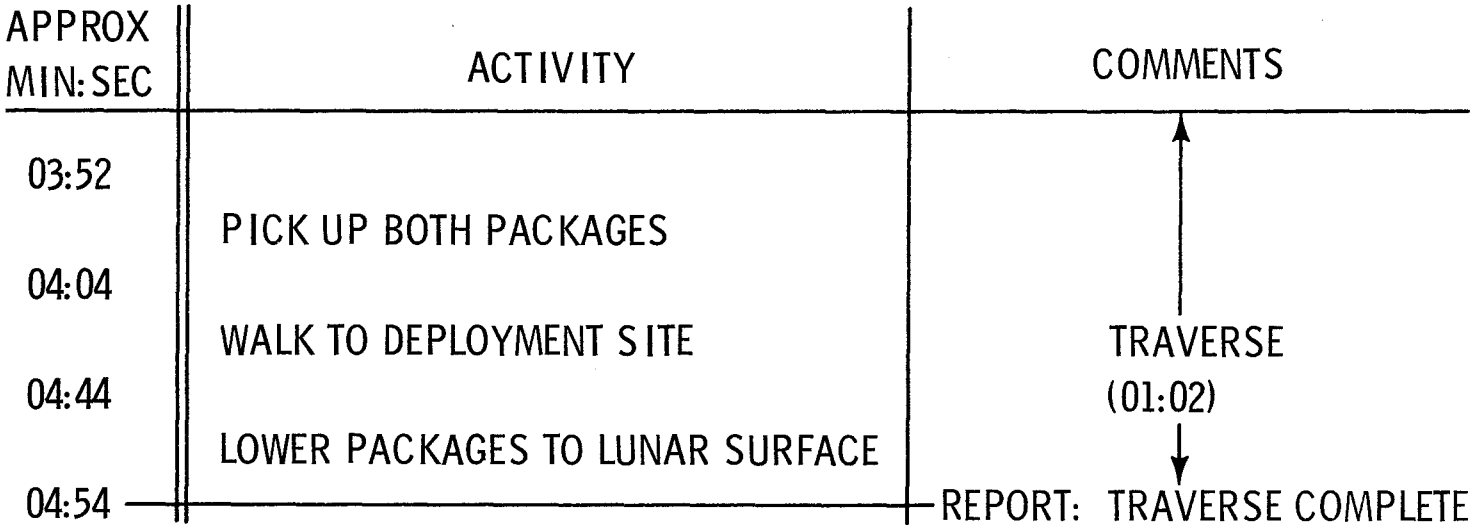
DEPLOYMENT TIMELINE (CONT.)



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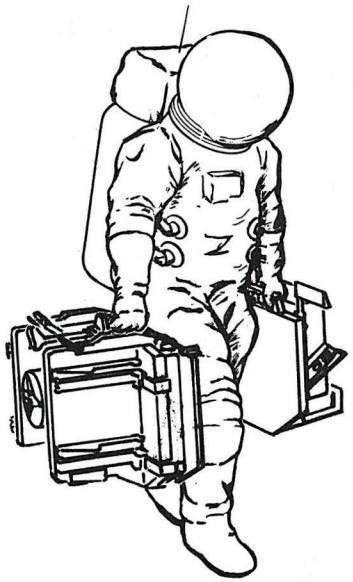
TRAVERSE



- PICK UP BOTH PACKAGES
- WALK TO DEPLOYMENT SITE
- SITE SELECTION
  - APPROXIMATELY 30 FT FROM LM,
  - IN FOV OF OTHER ASTRONAUT,
  - IN AN AREA FREE OF RUBBLE, i.e., beer cans, garbage, broken glass, old tires and rusty automobile bodies.
- LOWER PACKAGES TO LUNAR SURFACE

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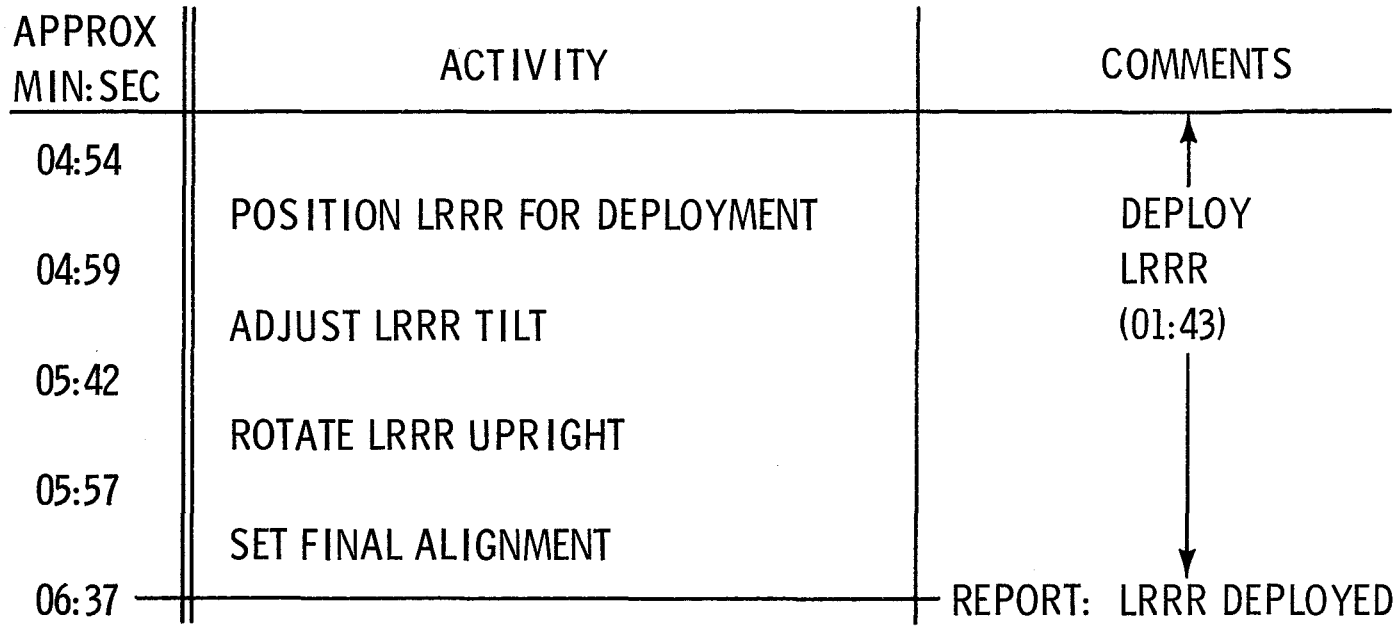
DEPLOYMENT TIMELINE (CONT.)



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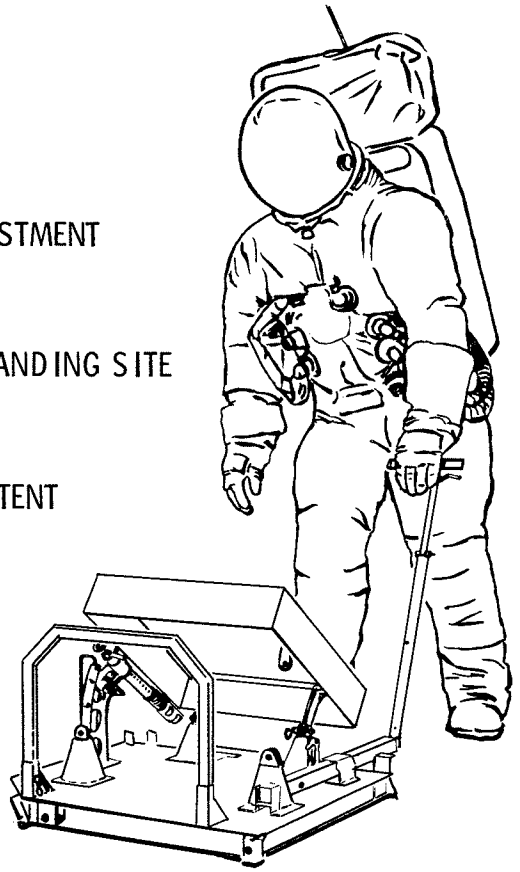
DEPLOY LRRR

- POSITION LRRR FOR DEPLOYMENT
  - ROUGH ALIGN LRRR WRT SUB-EARTH POINT
  - RELEASE DEPLOYMENT HANDLE AND EXTEND TO DETENT
  - PULL OUT ARRAY TILTING HANDLE TO ALLOW TILT ADJUSTMENT
- ADJUST LRRR TILT
  - ROTATE TILTING HANDLE TO SET TILT INDICATOR FOR LANDING SITE
- ROTATE LRRR UPRIGHT
  - ACTUATE DEPLOYMENT HANDLE TRIGGER TO RELEASE DETENT
  - FULLY EXTEND HANDLE
  - USE HANDLE TO ROTATE PACKAGE
- SET FINAL ALIGNMENT
  - ALIGN WRT SHADOW ON PARTIAL ROSE



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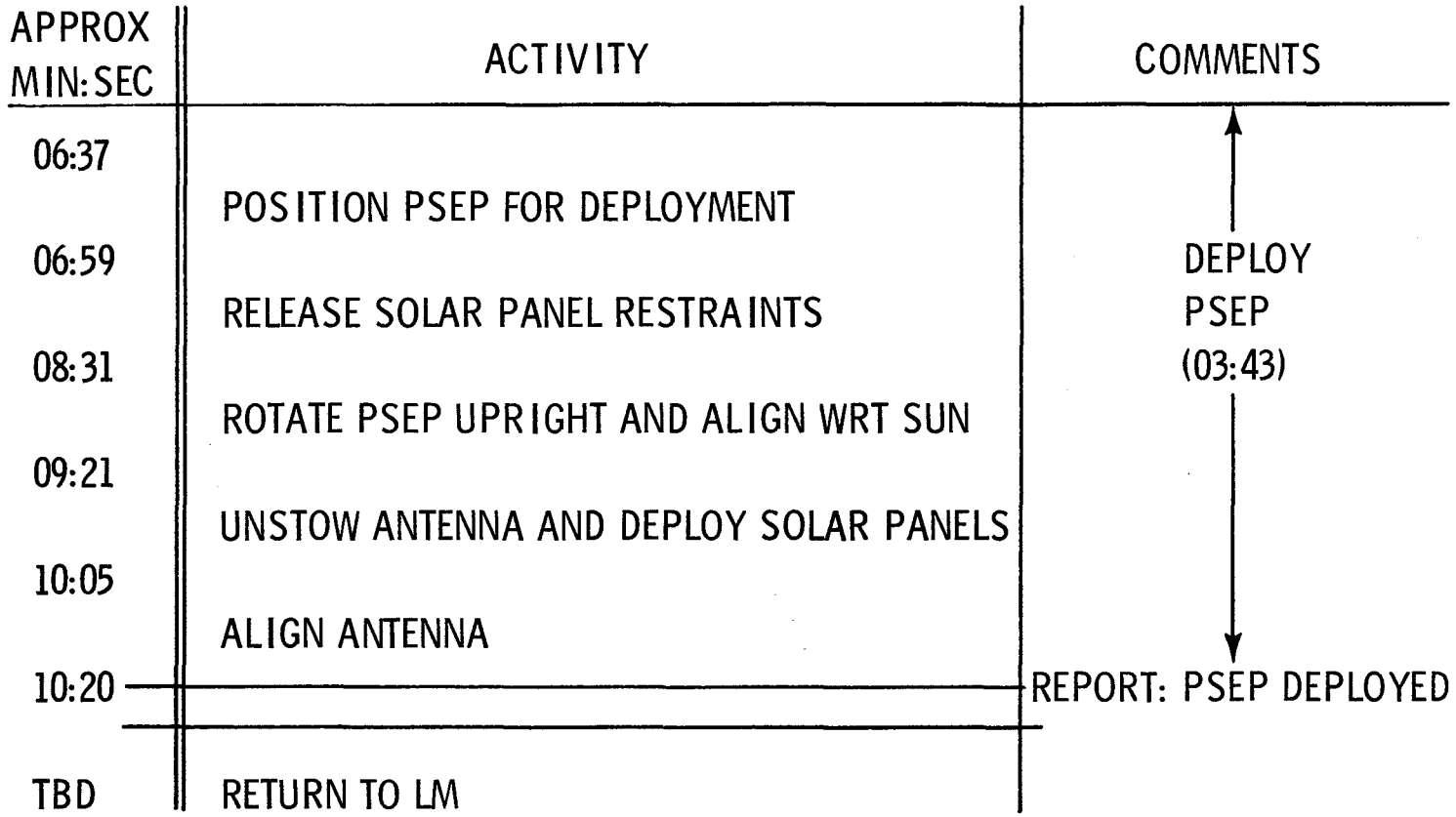
DEPLOYMENT TIMELINE (CONT.)



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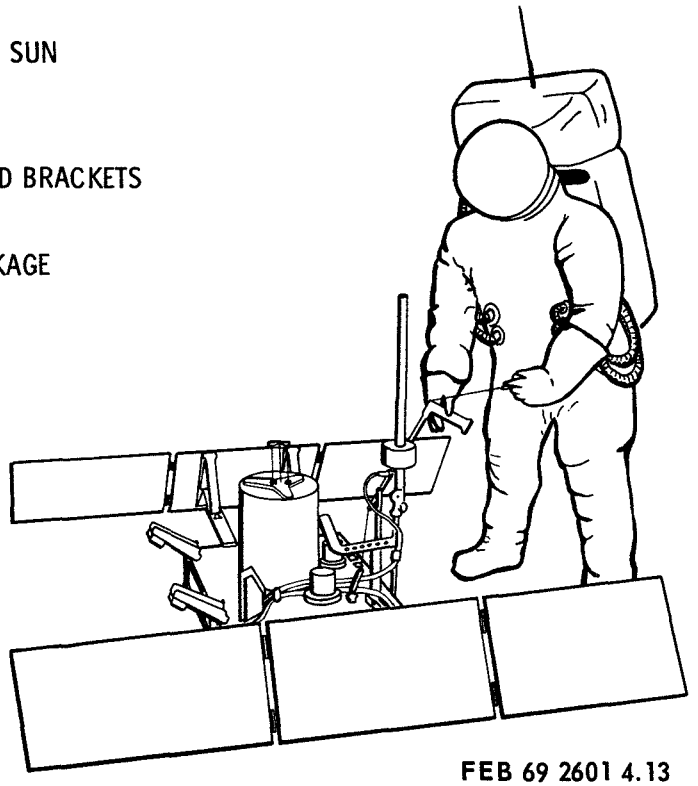
DEPLOY PSEP

- POSITION PSEP FOR DEPLOYMENT
  - PLACE 10 FT FROM LRRR, ALIGNING SOLAR PANELS WRT SUN
- RELEASE SOLAR PANEL RESTRAINTS
  - EXTEND AND LOCK DEPLOYMENT HANDLE
  - REMOVE/DISCARD SOLAR PANEL RESTRAINING PINS AND BRACKETS
- ROTATE PSEP UPRIGHT AND ALIGN WRT SUN
  - USE CARRY AND DEPLOYMENT HANDLES TO ROTATE PACKAGE
  - ALIGN WRT GNOMON SHADOW ON FULL ROSE
- UNSTOW ANTENNA AND DEPLOY SOLAR PANELS
  - USE ANTENNA RELEASE LANYARD TO REMOVE ANTENNA RESTRAINING PIN
  - ROTATE ANTENNA AND DISCARD LANYARD
  - USE SOLAR PANEL DEPLOYMENT LANYARD TO INITIATE UNFOLDING OF PANELS
- ALIGN ANTENNA
  - MANUALLY ROTATE ANTENNA TO SET TILT INDICATOR FOR LANDING SITE



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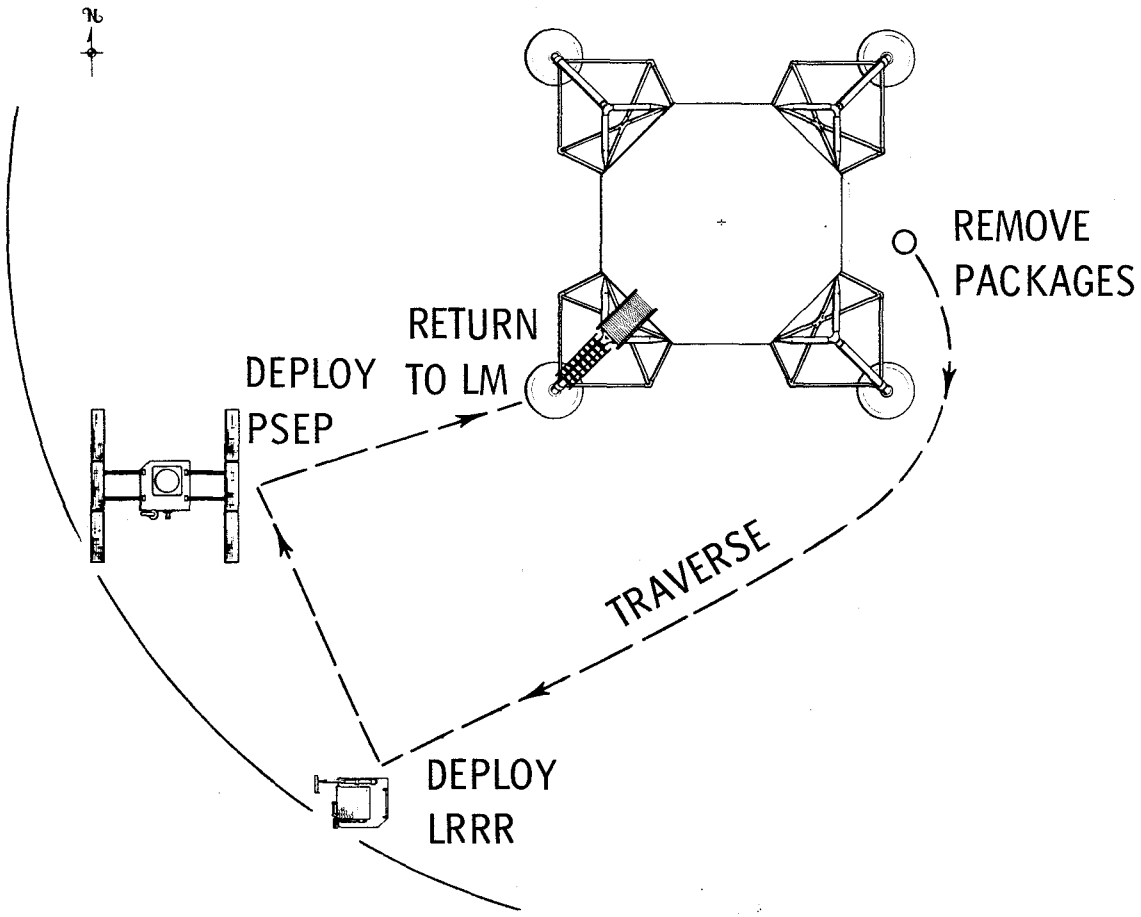
EASEP DEPLOYMENT SUMMARY



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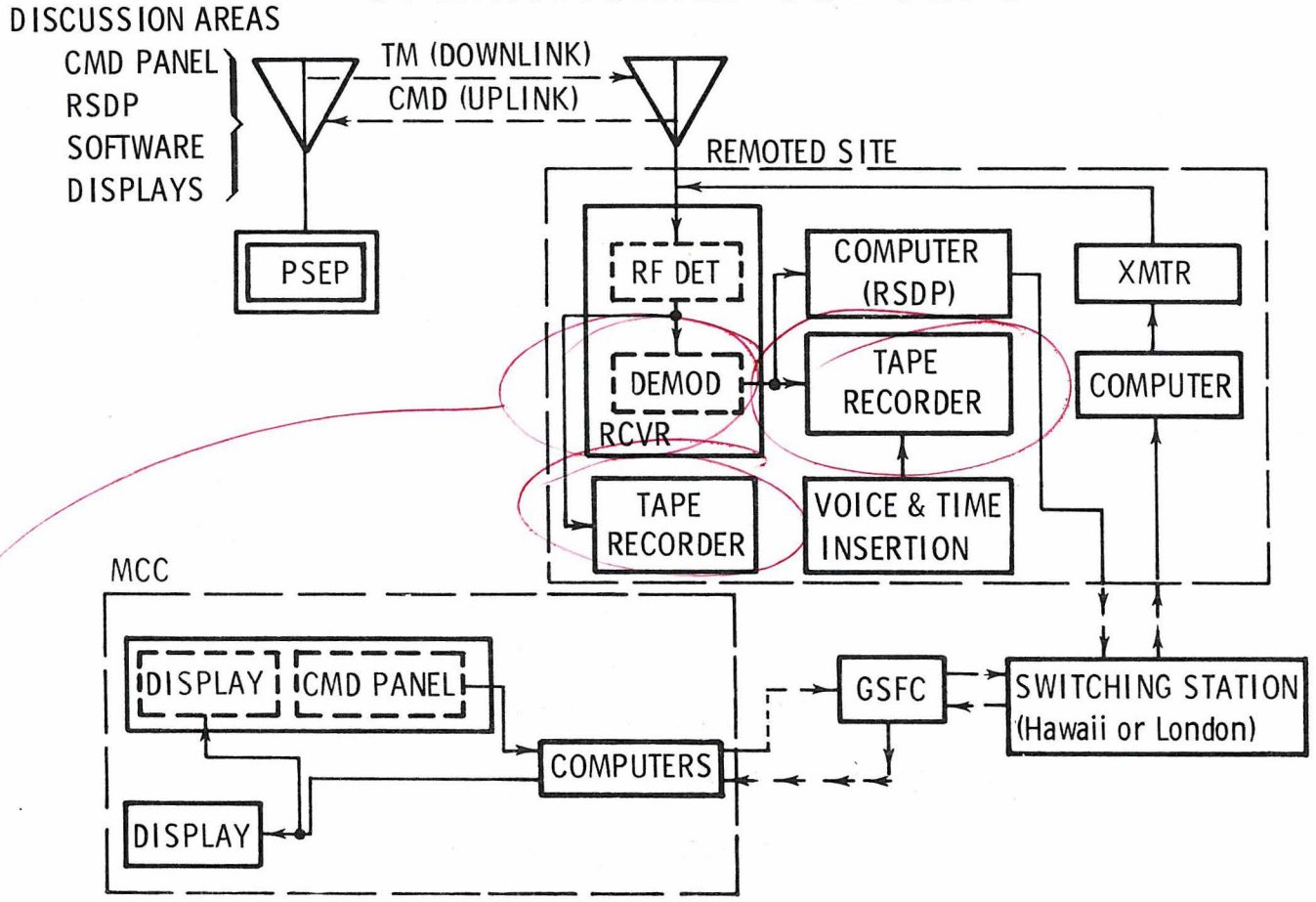
OPERATIONAL CONCEPT



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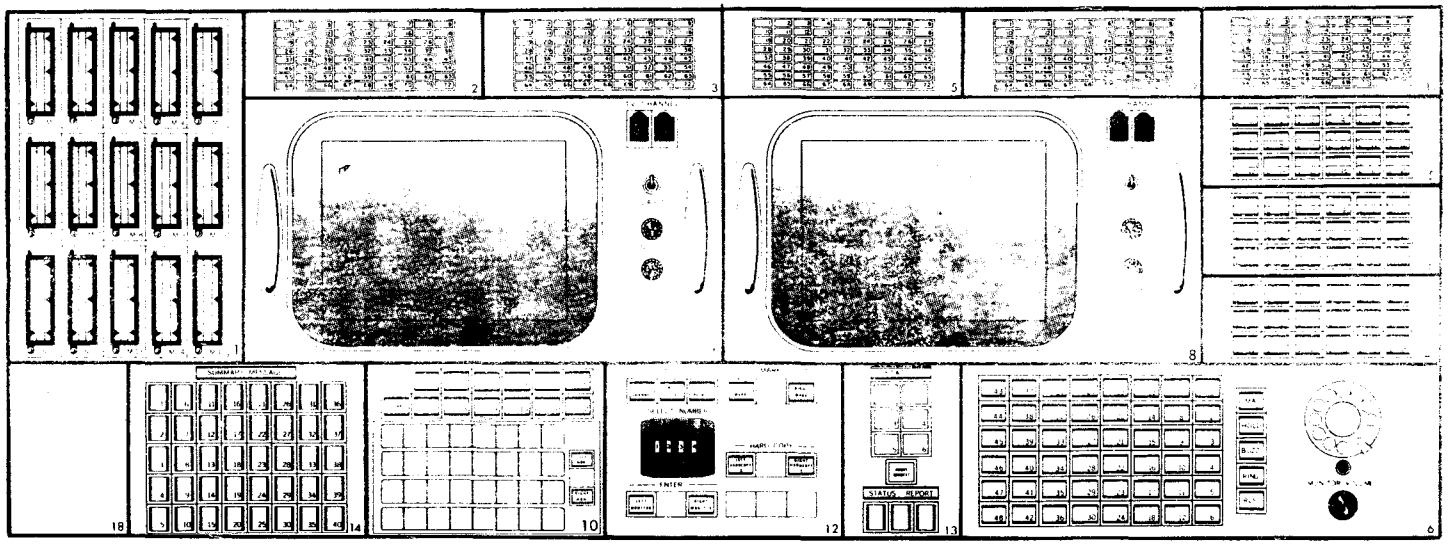
Why couldn't a strip chart recorder be fed the V's & T's plus time from this ground station?

MSFN/MCC OPERATIONS

OPERATIONAL CONCEPT

PSEP MISSION PHASE ACTIVITIES

- INITIAL CHECKOUT
- 45-DAY
- ONE-YEAR



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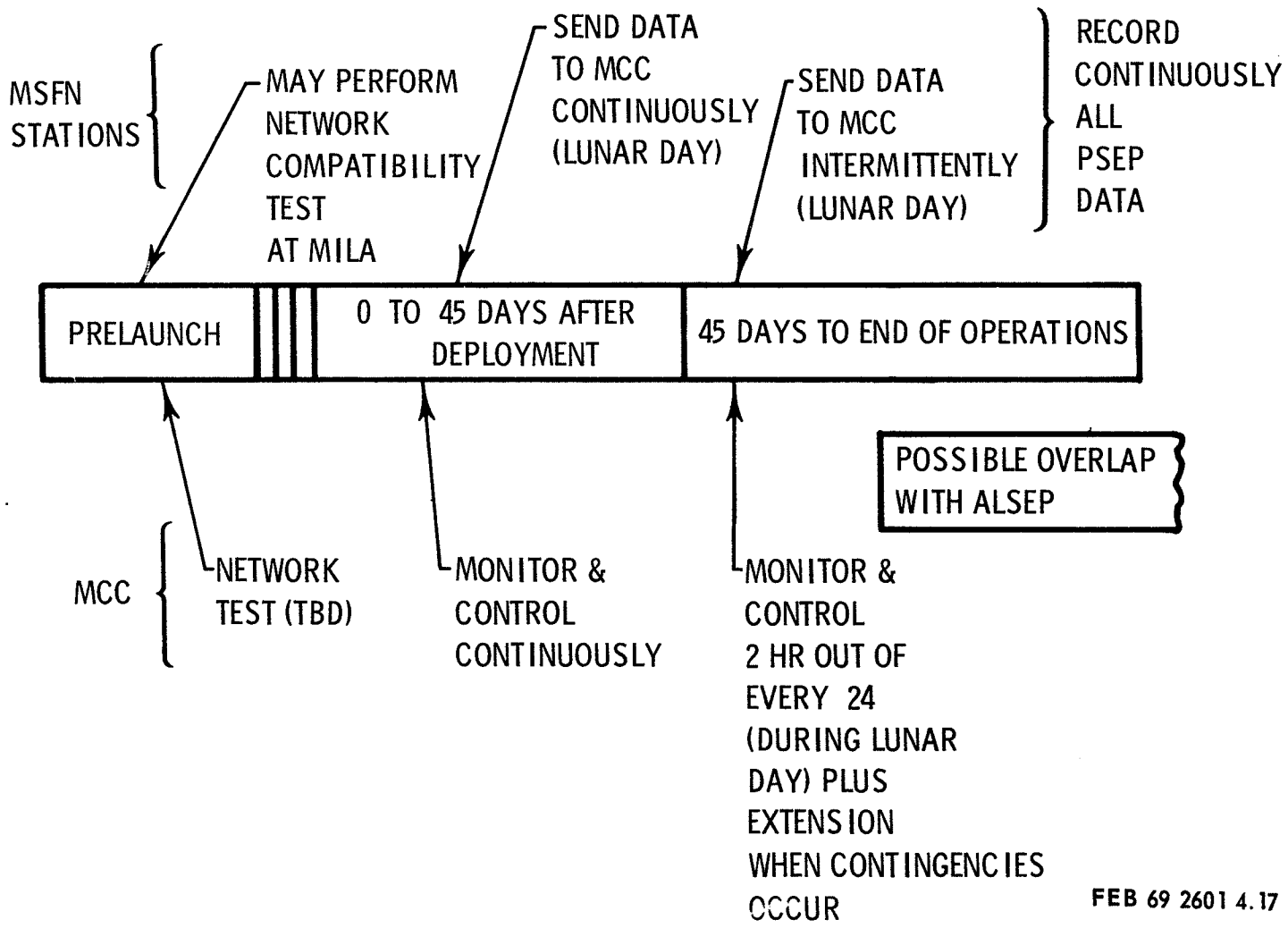
SCHEDULE OF MSFN/ MCC ACTIVITIES



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CMD AND TM SUMMARY

ONE PSEP & THREE ALSEPs (#1, #3, & #4)	
UPLINK (CMD)	DOWNLINK (TM)
• ONE FREQUENCY, 2119 MHz • 8 DECODER ADDRESSES, ONE PAIR FOR PSEP • CAPABILITY FOR 100 CMDs, 33 USED ON PSEP (7-BIT CMD ALLOWS 128, BUT 28 ARE NOT VALID) • ALL CMDs ARE RTCs, NO "LOAD" CAPABILITY IS REQUIRED • NO TIME-CRITICAL CMDs EXCEPT PSE FORCED LEVELING (BACKUP TO AUTO MODE) WHERE CMD IS SENT TWICE WITH TIME INTERVAL ± 10 SEC • MAX 1 CMD/SEC LIMITED BY DECODER	• DIFFERENT FREQUENCIES FOR PSEP & EACH ALSEP • DATA RATES: 1.06 KBPS NORMAL, 0.53 KBPS CONTINGENCY (ALSEP 4 HAS ADDITIONAL 10.6 KBPS HBR SELECTED BY CMD; USED ONLY PERIODICALLY TO SUPPORT ASE) • 30-FT MSFN ANTENNA ADEQUATE FOR NORM BIT RT; 85-FT REQD FOR HBR (ALSEP 4) • PSEP FRAME = 64 10-BIT WORDS (0.60377 SEC @ NORM BIT RT) • CMD VERIFICATION WORD (INC MAP) APPEARS ONLY ONCE IN TM STREAM FOR EACH CMD TRANSMITTED

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COMMAND CONSOLE PLAN

CMD PANEL ←
RSDP
SOFTWARE
DISPLAYS

TENTATIVE

- ALL PSEP & ALSEP CMDs FROM 1 CONSOLE
- USE UNIVERSAL CMD SYSTEM PANEL
  - ADDRESS: ANY ONE OF 8 DECODERS
  - COMMAND: ANY ONE OF 100 DESIGNATIONS (PREFERABLY OCTAL 003 TO 174)
  - EXECUTE

NOTES: (1) STANDARD VERIFICATION CHECKS (SUCH AS "GROUND REJECT") WILL BE INCORPORATED

(2) NO AUTOMATIC RETRANSMIT PROCEDURE

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TM PROCESSING AT MSFN SITES

CMD PANEL
RSDP ←
SOFTWARE
DISPLAYS

	MINIMUM REQUIREMENT	REMARKS
PSEP	• THROUGHPUT DATA TO MCC • DECOM ONLY FOR CMD VERIFICATION	• ALSEP 1 MAY OVERLAP PSEP • TWO 1.06 KBPS (NORMAL) DATA STREAMS ON ONE 2.4 KBPS LINE BASED ON 5 FRAMES IN 3 SEC (EACH) - FRAME = 640 BITS ≈ 0.604 SEC - CAPACITY = (5/3) (640/1000) = 1.067 KBPS, EACH
ALSEP 1 & 3	• THROUGHPUT 2 DATA STREAMS (MAX) TO MCC • DECOM ONLY FOR CMD VERIFICATION	
ALSEP 4	• SAME AS ABOVE FOR MAJORITY OF TIME • DURING ASE OPERATIONS - REDUCE (EDIT) DATA - SEND TO MCC ON 2.4 KBPS LINE (NO OTHER DATA STREAM)	• DURING ASE OPERATIONS - 10.6 KBPS DATA RATE - 85-FT ANT REQD • EXCEPT FOR ≈ 1 HR WHILE CREW IS ON LUNAR SURFACE, ASE CAN BE SCHEDULED FOR CONVENIENCE
RECORD 3 DATA STREAMS (MAX) PLUS RCVD STATION TIME		

FEB 69 2601 4.20

SOFTWARE

CMD PANEL
RSDP
SOFTWARE ←
DISPLAYS

- ONE CDP COMMAND PROGRAM WILL SUPPORT PSEP & ALL ALSEPS
- PSEP DECOM PROGRAM IDENTICAL TO PORTION OF ALSEP 1
- PSEP CAL CURVES MAY DIFFER FROM ALSEP 1
- IN ADDITION TO SUBCOMMUTATION & SUPER COMMUTATION, PSEP HAS PARAMETERS REQUIRING MORE COMPUTATION THAN ENG UNIT CONVERSION & LIMIT SENSING

DISPLAYS

CMD PANEL
RSDP
SOFTWARE
DISPLAYS ←

SUBSYSTEM	REAL-TIME MONITORING				HISTORY	
	H/S PRINTER OR CRT	METERS	ANALOG B&S	EVENT LIGHTS/CRT	H/S PRINTER OR SMEK	ANALOG B&S
POWER/DATA	L	H	H*	D	L+D	H*
PSE	L	H	B+S	D	L+D	B+S

LEGEND

L = LIMIT-SENSED PARAMETERS

H = HIGH-PRIORITY ANALOGS

H* = BRUSH RECORDER ONLY

A = ANALOG SEISMIC DATA (> 1 SAMPLE/SEC)

D = DISCRETE

B = 8-CHANNEL
BRUSH RECORDER
(SCIENCE DATA > 1 SAMPLE/SEC)

S = SINGLE-CHANNEL SEISMIC DRUM RECORDERS WITH VARIABLE BAND-PASS FILTERS

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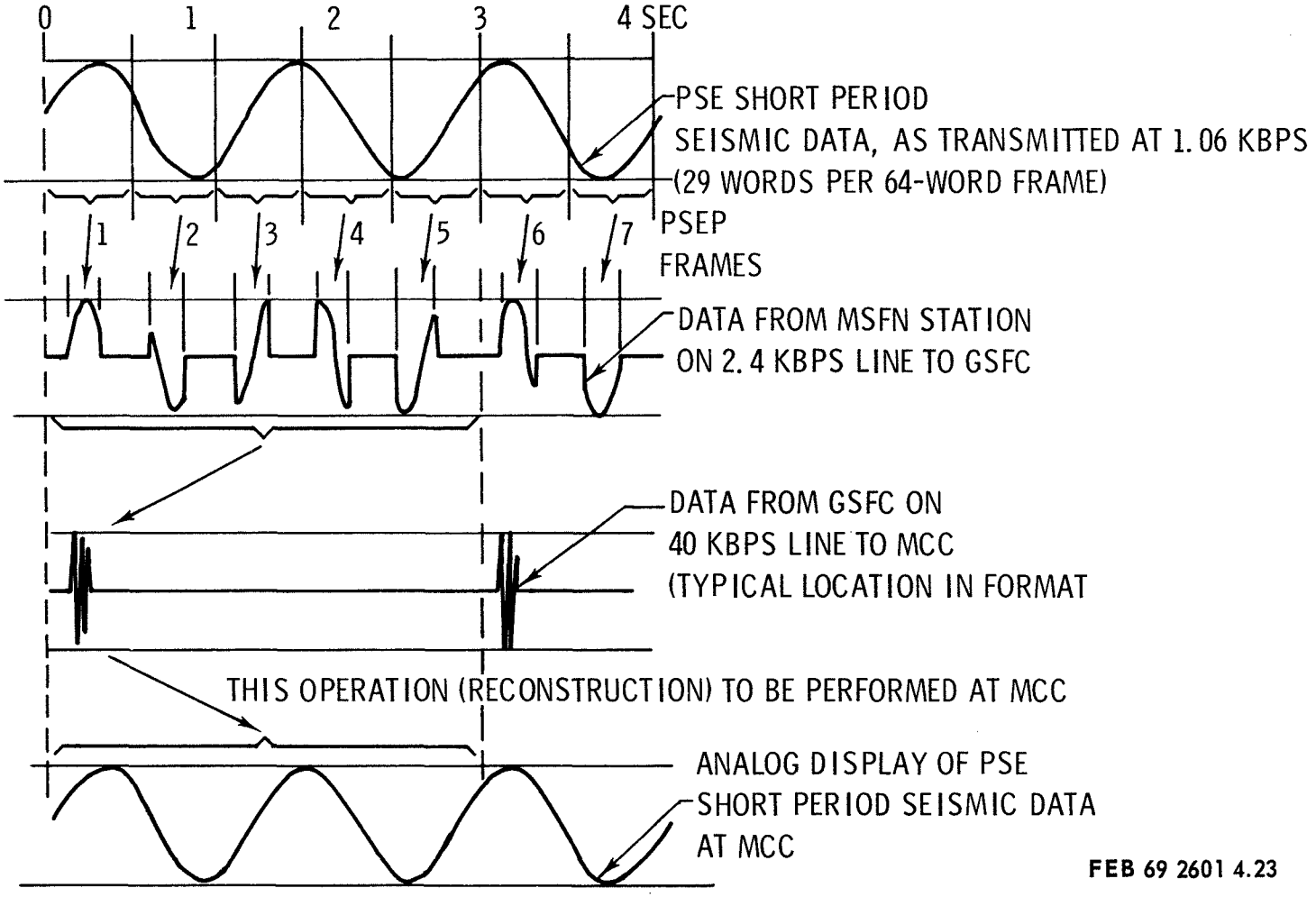
PSE DATA RECONSTRUCTION



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PSEP MISSION PHASES

SUBSYSTEM	MONITORING & CONTROL REQMT		
	INITIAL CHECKOUT PHASE	45-DAY PHASE	ONE-YEAR PHASE
POWER/DATA • START-UP • STATUS CHECKS • CORRECTIVE ACTIONS	 HI PRIORITY HI PRIORITY INITIAL ADJ	 -- PERIODIC MAY REQ CMD WITHIN 15 MIN	 -- INTERMITTENT MAY REQ CMD WITHIN 15 MIN
PSE • START-UP • CHECKOUT • SCIENTIFIC ADJ & CORRECTIVE ACTIONS	 2ND PRIORITY INITIAL ADJ PRINCIPAL INVESTIGATOR INPUTS SUPPLEMENTED BY PREPLANNED ROUTINES	 -- PERIODIC	 -- INTERMITTENT

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PSEP INITIAL CHECKOUT

- SYSTEM START-UP & ENG STATUS CHECKS
- PSE START-UP & CHECKOUT
- INTERACTION WITH APOLLO MISSION

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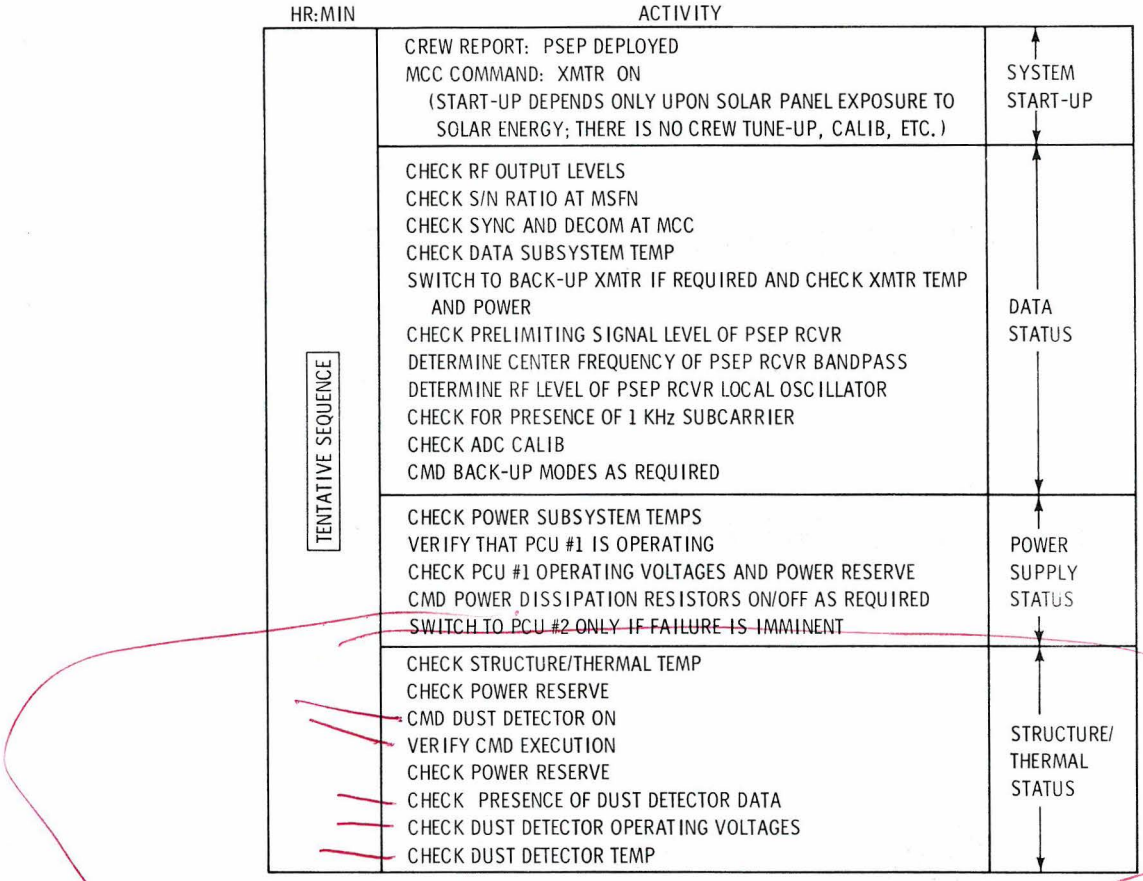
SYSTEM START-UP AND ENG STATUS CHECKS



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SYSTEM START-UP AND ENG STATUS CHECKS (CONT.)

HR:MIN	ACTIVITY	
TENTATIVE SEQUENCE	CHECK POWER RESERVE CHECK PSE POWER STATUS CMD PSE OPER VERIFY CMD EXECUTION RECHECK PSE POWER STATUS RECHECK POWER RESERVE	PSE START-UP
	CHECK SCI/ENG DATA OUTPUT UNCAGE (MAY OCCUR PRIOR TO LM ASCENT) LEVEL CALIBRATE CHECK PSE TEMP COLLECT BASELINE DATA	PSE CHECKOUT

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INTERACTION WITH APOLLO MISSION

- ACTIVITIES PHASED TO LM ASCENT
  - PSE UNCAGE MAY BE SCHEDULED PRE-ASCENT
  - MONITOR ALL SCIENTIFIC & ENGINEERING DATA BEFORE, DURING, & AFTER ASCENT TO DETERMINE EFFECTS OF LAUNCH (DUST DETECTOR IS A KEY MEASUREMENT)
- PRE-SLPASHDOWN CONSTRAINTS
  - IF NECESSARY DURING CRITICAL APOLLO MANEUVERS, PSEP XMTR MAY BE TURNED OFF.
  - OTHER APOLLO PRIORITIES MAY TAKE PRECEDENCE OVER PSEP PRIORITIES.

PSEP 45-DAY MISSION PHASE

- MONITOR ENGINEERING & SCIENCE DATA AGAINST LIMITS
- ESTABLISH ENGINEERING DATA TRENDS FOR USE DURING LATER INTERMITTENT OPERATIONS
- ADJUST PSE FOR OPTIMUM SCIENTIFIC DATA COLLECTION & CHANGING ENVIRONMENTAL CONDITIONS AS REQUESTED BY THE PRINCIPAL INVESTIGATOR
- APPLY CORRECTIVE COMMANDS FOR CONTINGENCIES, AS NECESSARY

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CRITICAL PSEP PARAMETERS

SUBSYSTEM	CONTINGENCY	CORRECTIVE ACTION
POWER	1. ABNORMAL SOLAR PANEL TEMPS 2. ABNORMAL PCU SHUNT CURRENT 3. ABNORMAL PCU TEMPS OR VOLTAGES	1. NO CORRECTIVE ACTION 2. ADJUST LOAD (PDR & PSE) 3. PREPARE TO SWITCH TO PCU 2
DATA	1. LOSS OF CARRIER, MODULATION OR SYNC 2. WEAK OR NOISY SIGNAL 3. LOSS OF 6 OR 15 ANALOG CHANNELS 4. SUBCOMM DATA NOT OK 5. NON-ZERO IN CV WORD WHEN NO CMD WAS SENT (INCIPIENT DECODER LOCKOUT) 6. ABNORMAL TEMPS	1. SWITCH TO ALTERNATE XMTR OR DATA PROCESSOR 2. SWITCH TO LOW BIT RT 3. SWITCH DATA PROCESSORS 4. SWITCH DATA PROCESSORS 5. SWITCH TO ALTERNATE DATA PROCESSOR BEFORE SENDING ANY OTHER CMDs 6. SWITCH TO REDUNDANT EQUIP
PSE	1. INSTRUMENT OFF-LEVEL (INDICATED BY TIDAL DATA) 2. SEISMIC DATA OFF SCALE OR INSIGNIFICANT 3. ERRATIC TIDAL DATA 4. ABNORMAL TEMPS (MAY REQUIRE CMD WITHIN 15 MIN)	1. CMD LVL, AS DIRECTED BY PRINCIPAL INVESTIGATOR 2. ADJUST AMPLIFIER GAINS 3. CMD PSE FILT OUT 4. CMD PSE HTR FORCED ON/OFF (OR PWR STBY)

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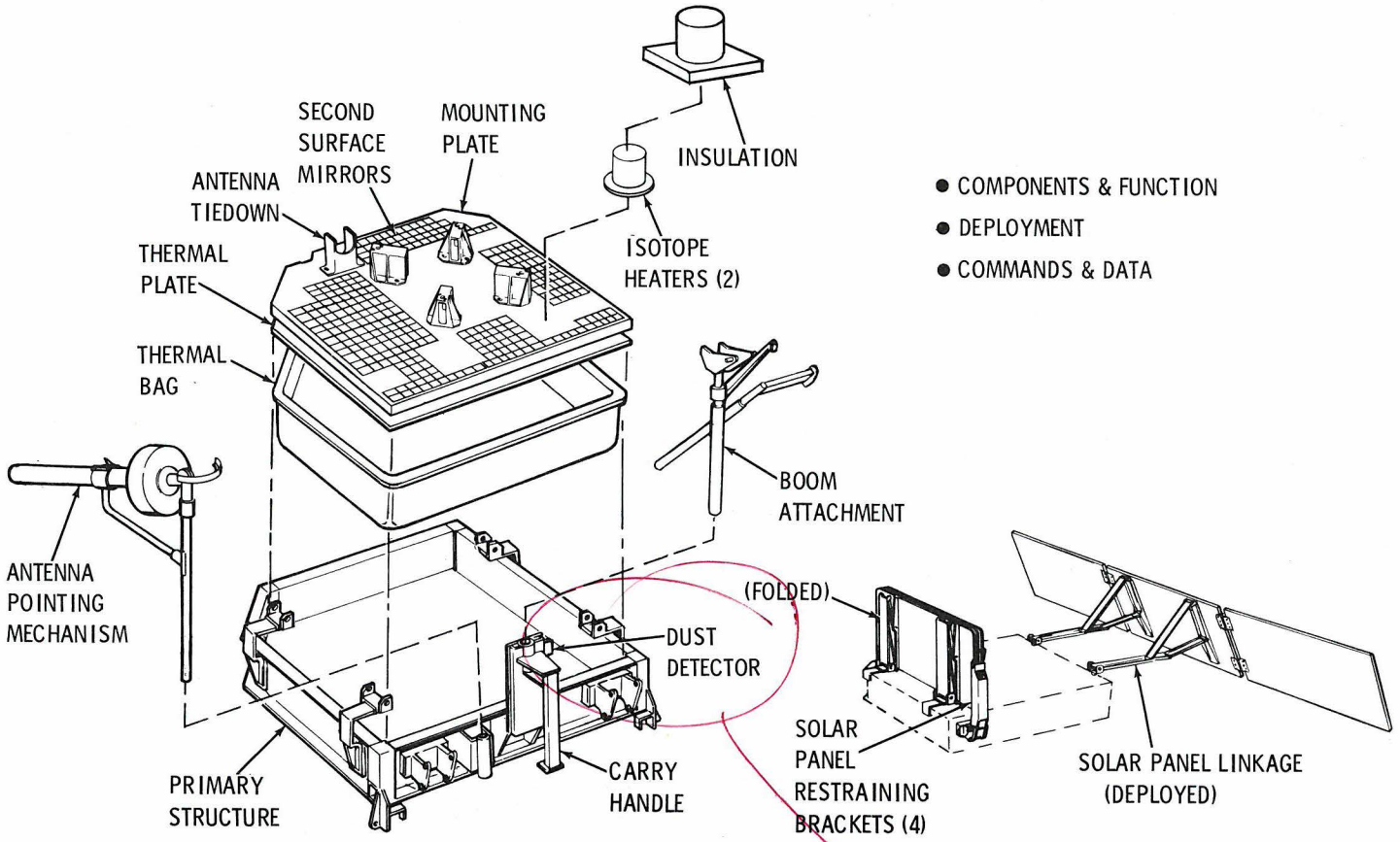
PSEP ONE-YEAR MISSION PHASE
FROM 45TH DAY AFTER DEPLOYMENT

1. BRING BIT STREAM IN BUILDING, DECOM, PROCESS, & BRING UP DISPLAYS; MEANWHILE, VERIFY THAT CMD PANEL IS HOT
2. CHECK CMD FUNCTION STATUS FOR CHANGES SINCE END OF PREVIOUS MONITORING PERIOD
3. COMPARE POWER/THERMAL STATUS TO FORECAST
4. OBSERVE CRITICAL PARAMETERS FOR ANOMALIES; IF ANY EXIST, LOG STATUS, DETERMINE CAUSES, & CMD AS APPROPRIATE
5. EXAMINE PSE FOR SATISFACTORY DATA; SEND CORRECTIVE CMDs, IF NECESSARY
6. MAINTAIN LOG OF ALL CMDs SENT & STATUS CHANGES

PSEP STRUCTURE/THERMAL SUBSYSTEM



- COMPONENTS & FUNCTION
- DEPLOYMENT
- COMMANDS & DATA

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MECHANICAL CRITERIA

STRUCTURAL ELEMENTS

- WITHSTAND LOADS OF LAUNCH, FLIGHT, & LUNAR LANDING
- WITHSTAND LOADS ASSOCIATED WITH DEPLOYMENT
- SUPPORT THE EQUIPMENT ON THE LUNAR SURFACE

JOINTS, FITTINGS & FASTENERS

- HOLD SECURELY IN LOCKED POSITIONS
- RELEASE & FUNCTION DURING DEPLOYMENT

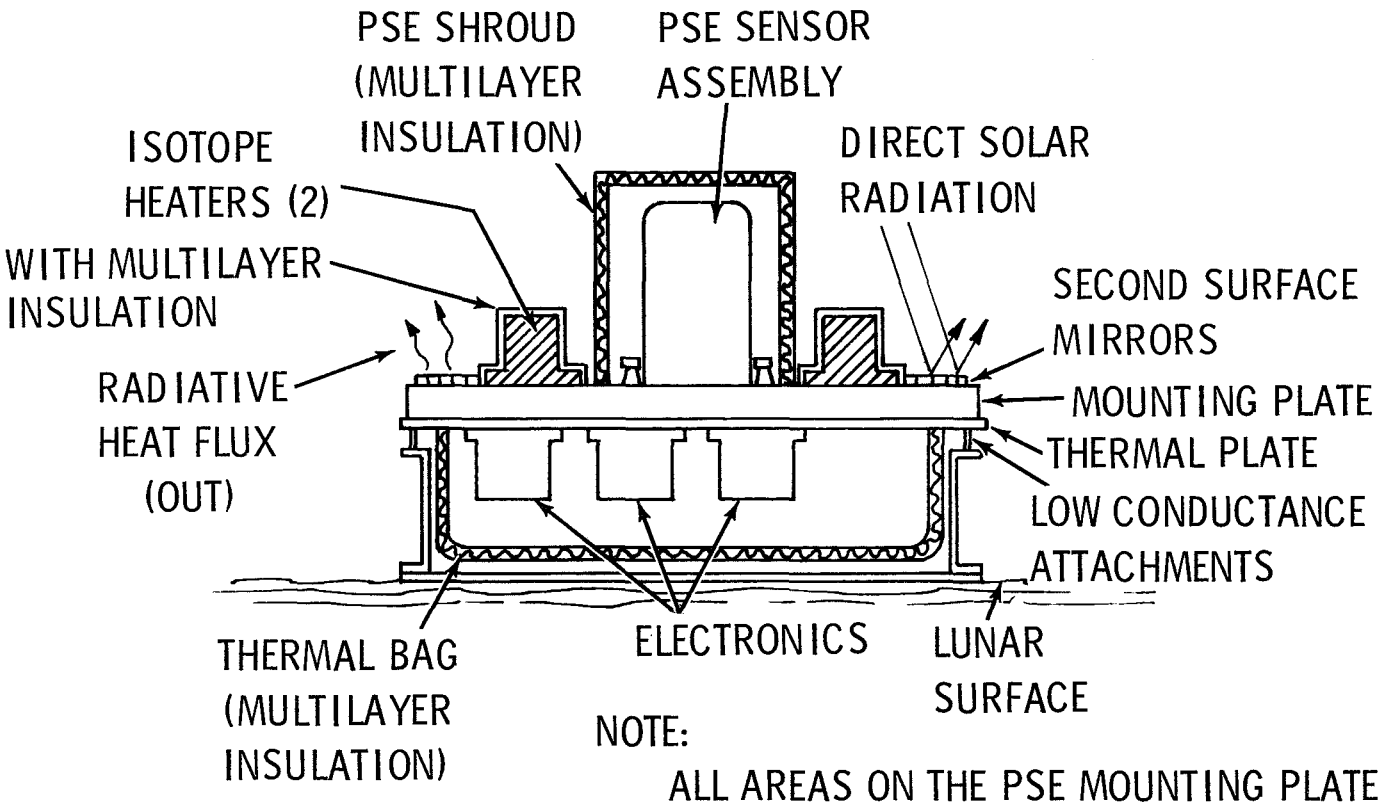
SPECIAL JIGS & SHIPPING CONTAINERS PROVIDE PROTECTION FOR PRELAUNCH HANDLING, TRANSPORTATION, & STORAGE

PSEP THERMAL CRITERIA AND CONCEPT

LUNAR DAY OPERATION (SURFACE TEMP AS HIGH AS 250° F)

- MAINTAIN AVERAGE TEMPERATURE IN THE FOLLOWING RANGES:
  - CENTRAL ELECTRONICS THERMAL PLATE BETWEEN 0° & 140° F FOR RELIABLE OPERATION
  - PSE SENSOR ASSEMBLY BETWEEN 0° & 140°
- SYSTEM CONCEPT:
  - ISOLATE ELECTRONICS AND EXPERIMENT FROM LUNAR SURFACE & SOLAR HEAT INPUTS
  - TAILOR RADIATOR PLATE AND MASK AREA TO RANGE OF INTERNAL ELECTRICAL DISSIPATION (PLUS ISOTOPE HEATER INPUT)
  - SECOND SURFACE MIRRORS AND THERMAL PLATE MINIMIZE SOLAR HEAT INPUT
- LUNAR NIGHT SURVIVAL (SURFACE TEMP AS LOW AS -300°F)
  - MAINTAIN AVERAGE THERMAL PLATE TEMP AT OR ABOVE -65° F
  - PROVIDED BY ISOLATION FROM SURFACE, ISOTOPE HEATERS, AND RADIATING SURFACE CHARACTERISTICS

PSEP THERMAL CONTROL



NOTE:

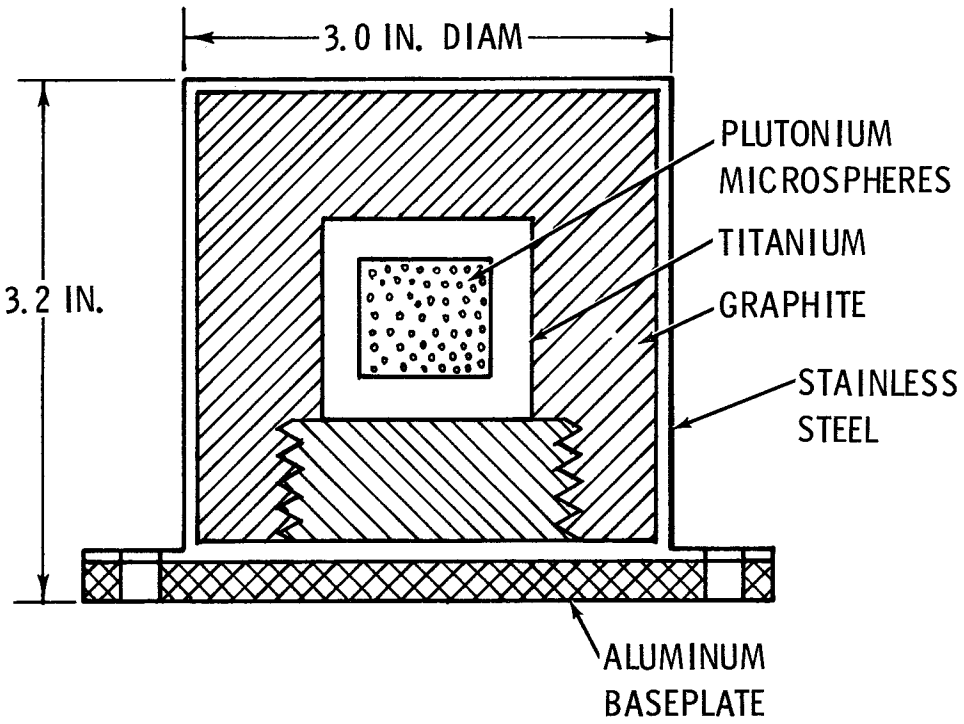
ALL AREAS ON THE PSE MOUNTING PLATE NOT COVERED WITH SECOND SURFACE MIRRORS OR COMPONENTS ARE COVERED WITH MULTILAYER INSULATION MASKS

FEB 69 26015.4

PSEP THERMAL DESIGN TECHNIQUES

- MULTILAYER INSULATION ON SIDES & BOTTOM OF ELECTRONICS COMPARTMENT (ALSO PSE SHROUD) MINIMIZES RADIATIVE HEAT TRANSFER IN AND OUT THROUGH THESE SURFACES
- LOW CONDUCTANCE ATTACHMENTS REDUCE HEAT TRANSFER BETWEEN LUNAR SURFACE & THERMAL PLATE (THROUGH PRIMARY STRUCTURE)
- OPERATING POWER (THERMAL DISSIPATION) OF ELECTRONICS, DURING LUNAR DAY, IS CONDUCTED THROUGH THERMAL PLATE TO MOUNTING PLATE
- PSE OPERATING POWER (LUNAR DAY) & ISOTOPE HEATER THERMAL ENERGY (DAY/NIGHT) IS CONDUCTED TO MOUNTING PLATE
- SECOND SURFACE MIRRORS ON UPPER SURFACE OF MOUNTING PLATE REFLECT MOST OF INCIDENT SOLAR ENERGY (LUNAR DAY)
- SECOND SURFACE MIRRORS RADIATE DAY TIME THERMAL DISSIPATION OF THE ELECTRONICS, PSE SENSOR AND ISOTOPE HEATERS TO SPACE
- THE TEMPERATURE OF THE MIRRORS DROPS 205°F AT NIGHT AND LIMITS THE RADIATION TO SPACE TO 1/5 THE DAY TIME VALUE.
- PSEP ELECTRONICS AND PSE SENSOR ARE THERMALLY COUPLED TO THE THERMAL PLATE.

ISOTOPE HEATERS



- PSEP USES TWO HEATERS TO AID IN LUNAR NIGHT SURVIVAL WHEN ELECTRONICS ARE NOT OPERATING
- CHARACTERISTICS (EACH):
  - PLUTONIUM: 36 GRAMS
  - DOSAGE RATE: 0.62 MILLIREM/HR AT ONE METER (VARIES WITH DIRECTION)
  - THERMAL OUTPUT: 15 WATTS EACH

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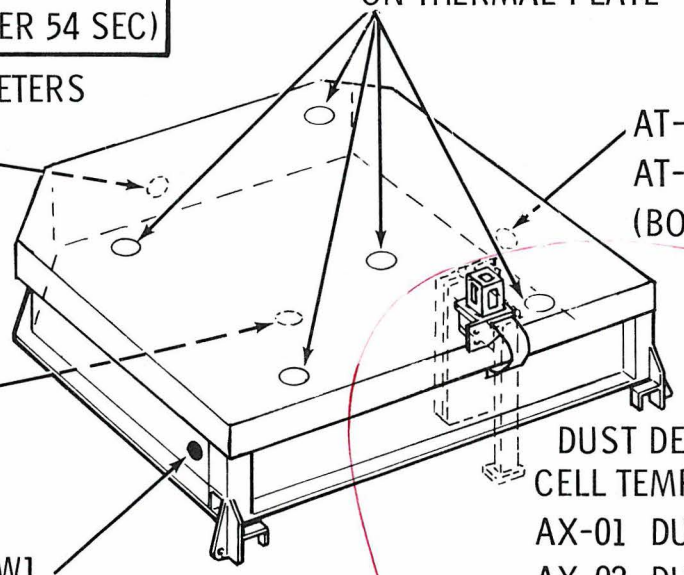
STRUCTURE/THERMAL SENSOR LOCATIONS

CODE AT, AX, ETC.
INDICATES DATA VIA
PSEP ANALOG MULTIPLEXER
(READ OUT ONCE PER 54 SEC)

TOTAL 17 PARAMETERS



AT-03 THROUGH AT-07
ON THERMAL PLATE

AT-12 INSUL INT
AT-13 INSUL EXT
(BOTH ON WALL)

AT-11 PRI/ST W3
(ON BACK PANEL)

AT-10 PRI/ST B
(ON BOTTOM)

AT-08 PRI/ST W1
AT-09 PRI/ST W2 (ON OPPOSITE WALL)

DUST DETECTOR
CELL TEMP & OUTPUT

AX-01 DUST CELL 1 DEG F
AX-02 DUST CELL 2 DEG F
AX-03 DUST CELL 3 DEG F
AX-04 DUST 1 OUT MW/CM2
AX-05 DUST 2 OUT MW/CM2
AX-06 DUST 3 OUT MW/CM2

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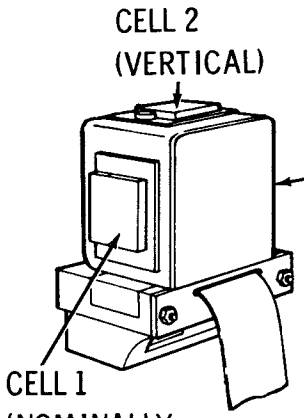
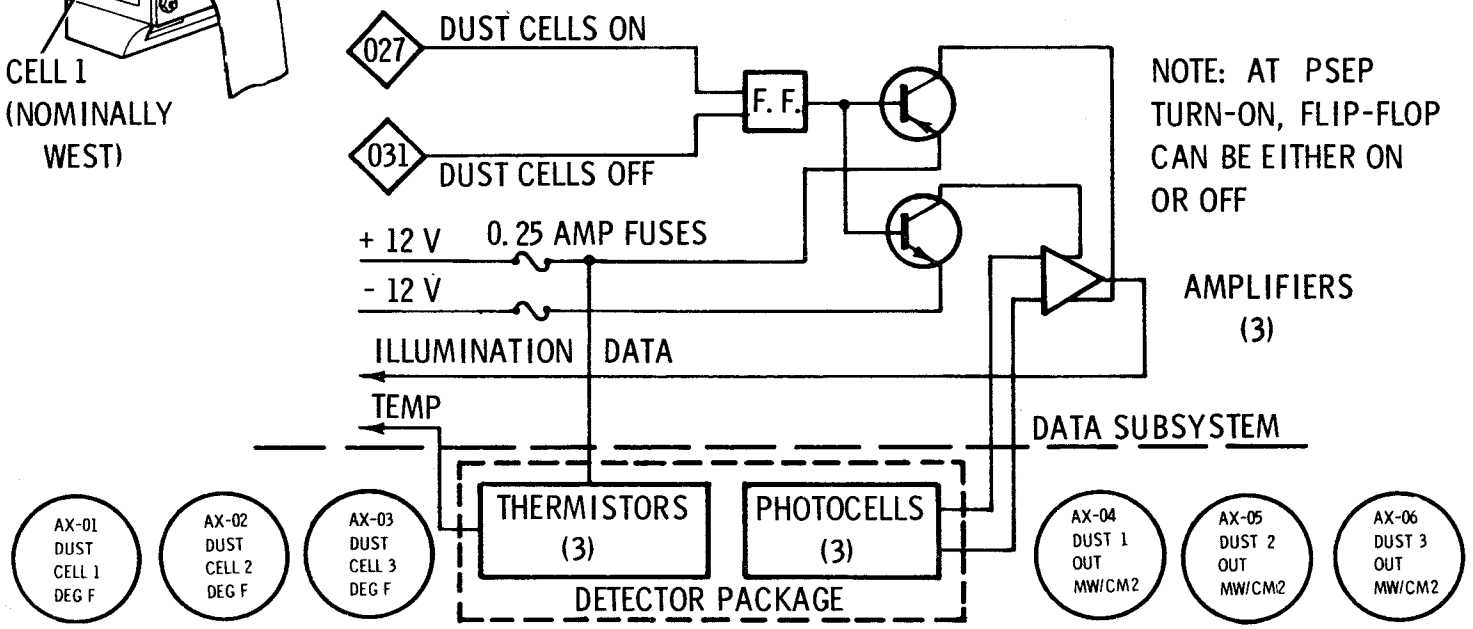
DUST DETECTOR



- TO ASSESS DUST ACCRETION ON PSEP & INFER DEGRADATION OF THERMAL SURFACES
- USES THREE 2 CM X 2 CM PHOTOCELLS, EACH HAVING:
  - BLUE FILTER TO CUT OFF UV BELOW 0.4 MICRONS
  - 0.060-IN. FUSED SILICA RADIATION PROTECTION
  - THERMISTOR ON REAR TO MONITOR TEMP



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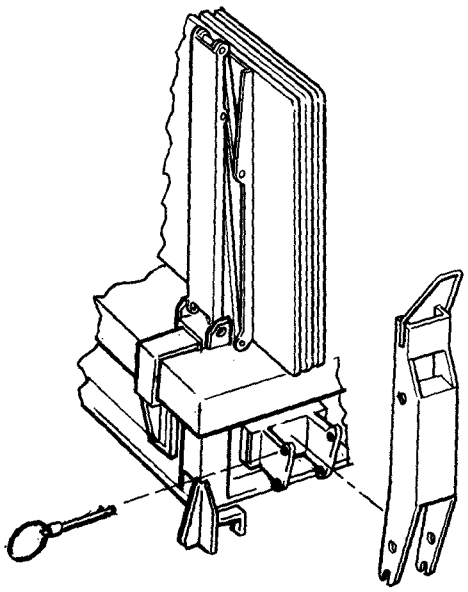
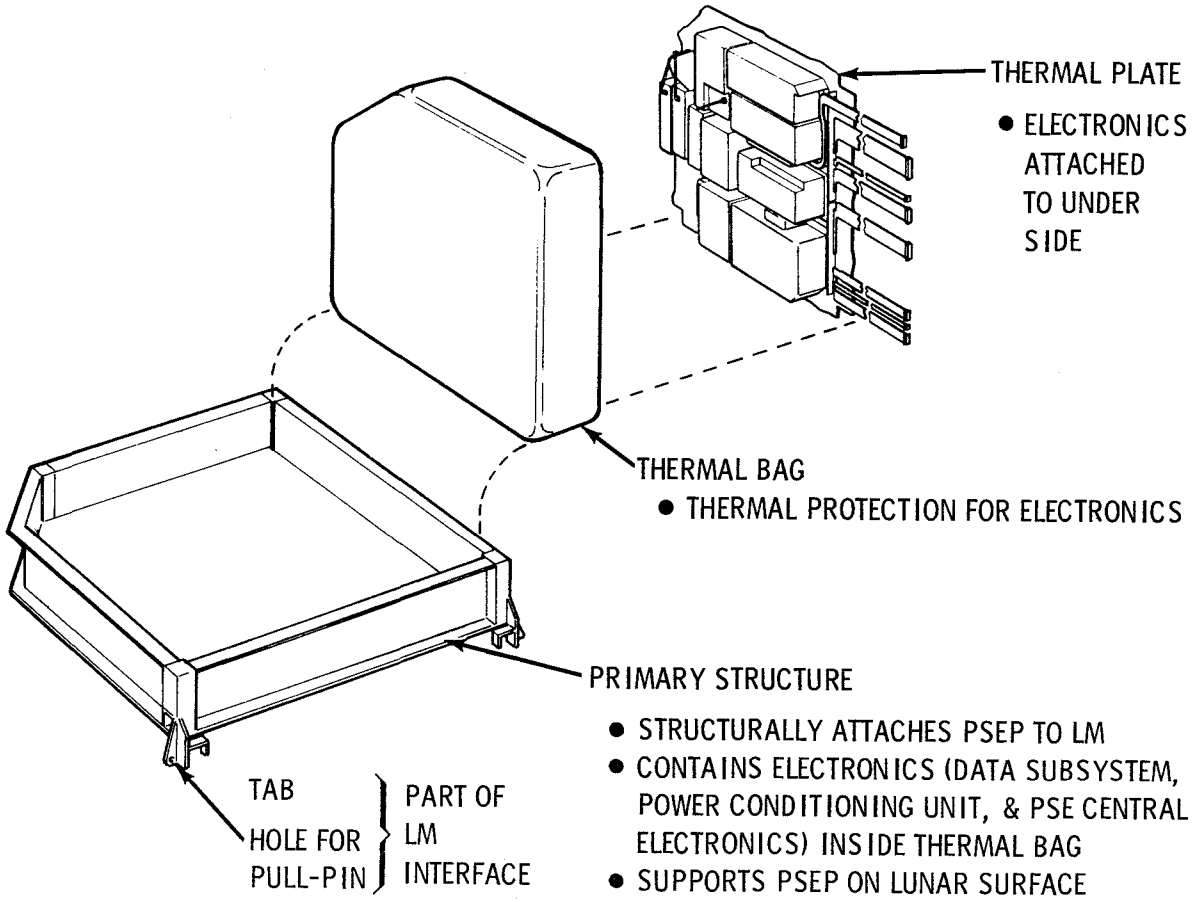
PULL-PIN FASTENERS



- SPRING-LOADED DETENT BALLS
- USED FOR SHEAR CONNECTIONS ON:
  - PSEP/LM INTERFACE
  - BOOM & HANDLE ASSEMBLY
  - SOLAR PANEL RESTRAINTS
  - ANTENNA TIE-DOWN

PRIMARY STRUCTURE, BAG AND THERMAL PLATE



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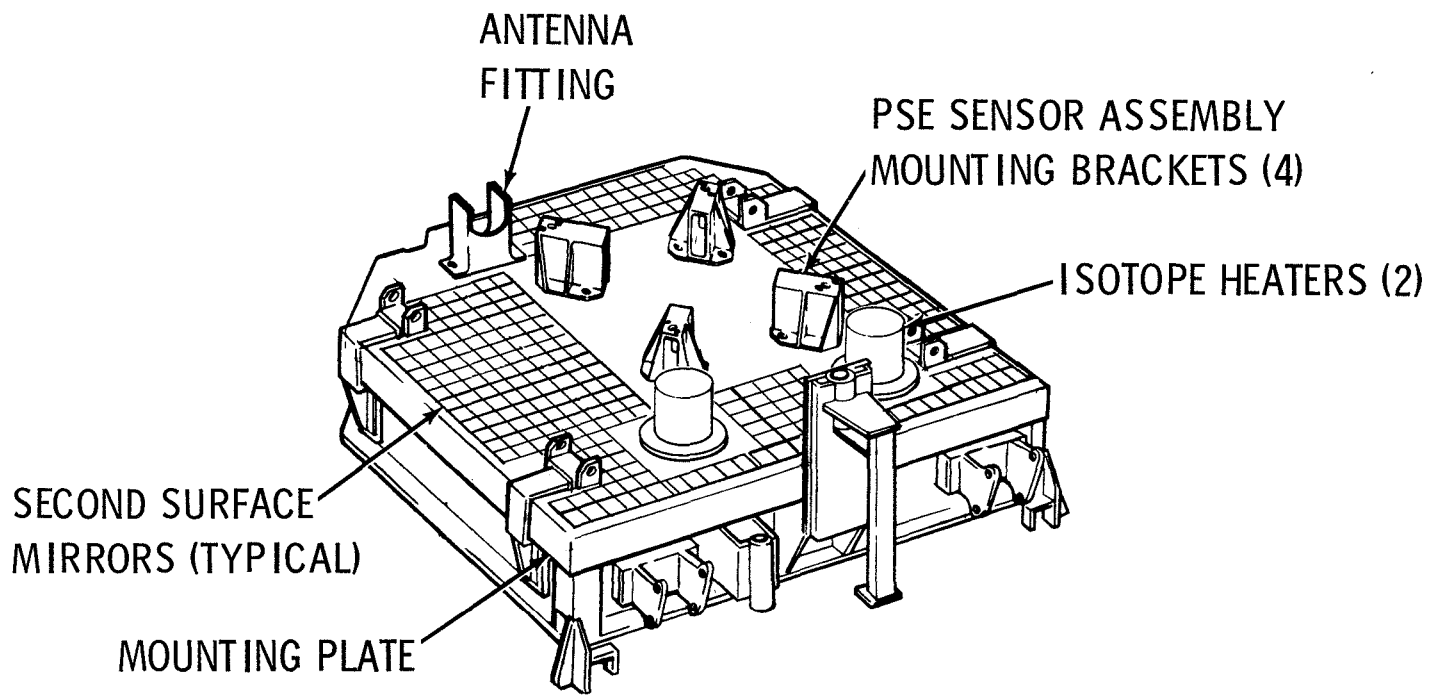
MOUNTING PLATE



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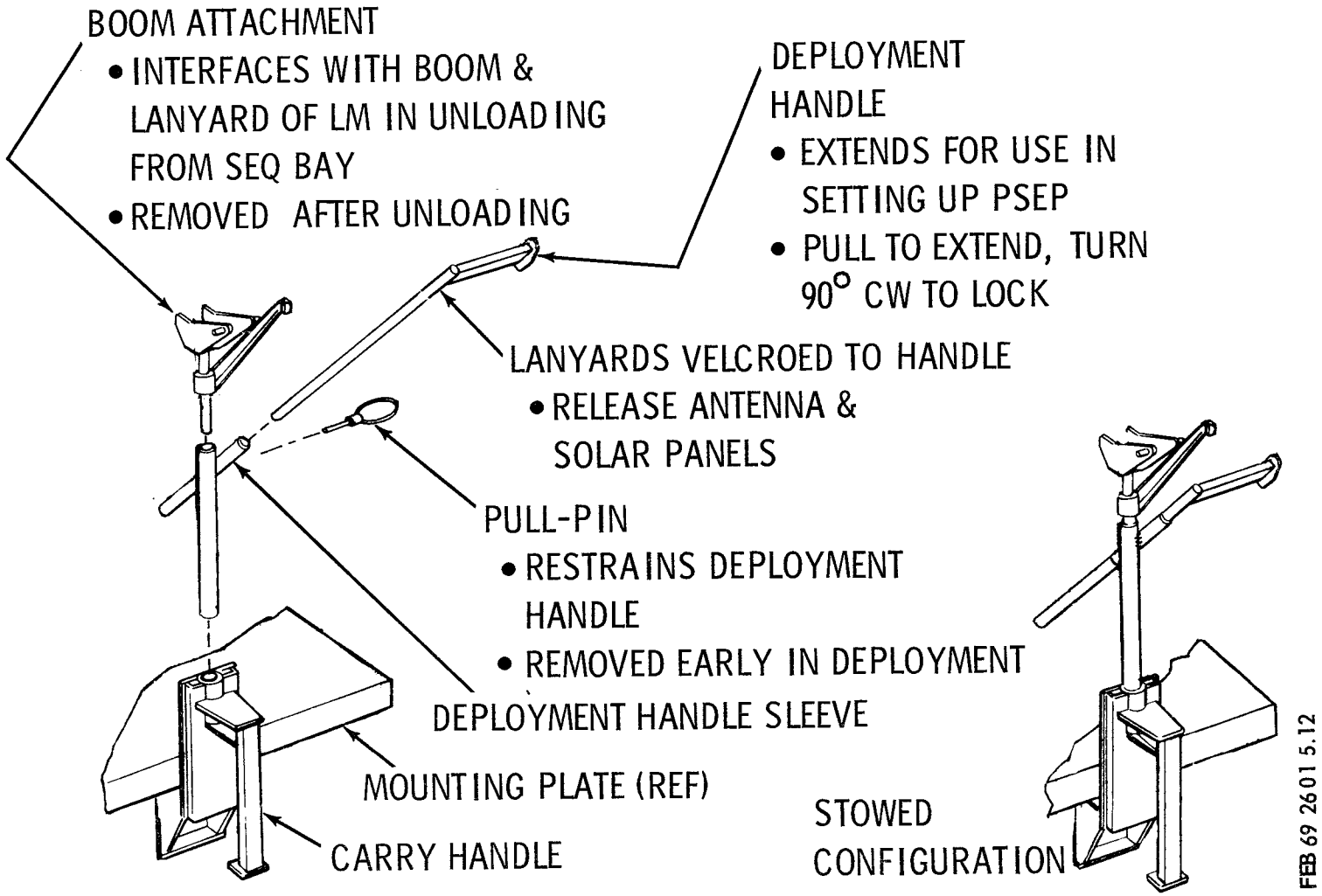
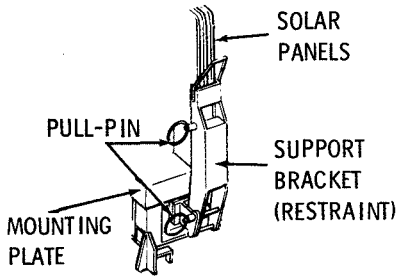
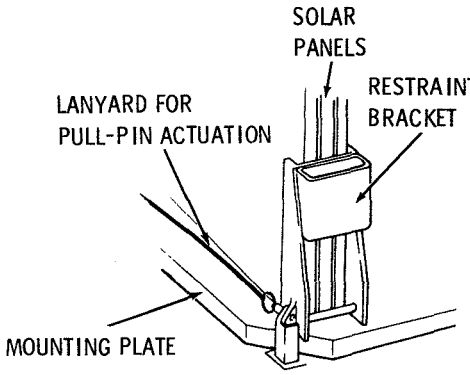
BOOM AND HANDLE ASSEMBLY



SOLAR PANEL RESTRAINTS AND LINKAGE

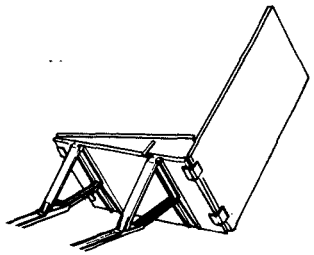


FRONT RESTRAINTS (2)



REAR RESTRAINTS (2)

PANEL HINGES



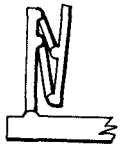
ASTRONAUT TASKS:

- BEFORE ROTATING PSEP UPRIGHT
  - EXTEND DEPLOYMENT HANDLE
  - REMOVE/DISCARD FRONT PULL-PIN
  - REMOVE/DISCARD BRACKET
  - REPEAT FOR 2ND PIN & BRACKET
- AFTER ROTATING PSEP UPRIGHT
  - HOLD DEPLOYMENT HANDLE WITH ONE HAND TO STEADY PSEP
  - REMOVE LANYARD FROM VELCRO
  - PULL LANYARD TO RELEASE PANELS

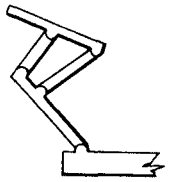
NOTE: HINGES/LINKAGES ARE SPRING-LOADED

LINKAGE MOTION

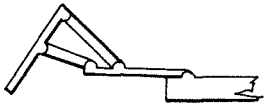
INITIAL POSITION



MID POSITION



FINAL POSITION



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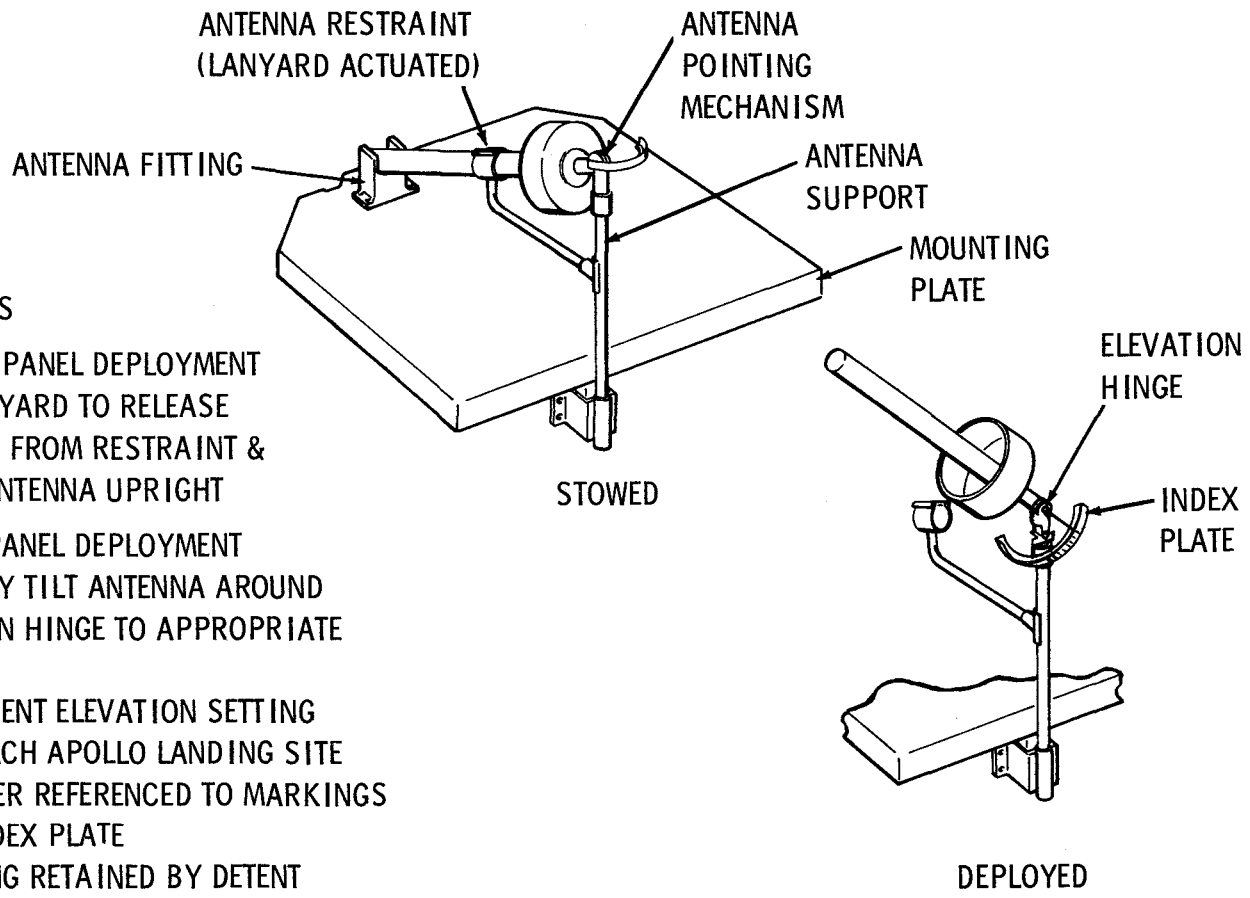
ANTENNA RELEASE AND ALIGNMENT



ASTRONAUT TASKS

- BEFORE SOLAR PANEL DEPLOYMENT
  - PULL LANYARD TO RELEASE PULL-PIN FROM RESTRAINT & ROTATE ANTENNA UPRIGHT
- AFTER SOLAR PANEL DEPLOYMENT
  - MANUALLY TILT ANTENNA AROUND ELEVATION HINGE TO APPROPRIATE SETTING

NOTES:
1. DIFFERENT ELEVATION SETTING FOR EACH APOLLO LANDING SITE
2. POINTER REFERENCED TO MARKINGS ON INDEX PLATE
3. SETTING RETAINED BY DETENT

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PSEP EMPLACEMENT CRITERIA

PARAMETER	REQUIREMENT	INDICATOR	COMMENTS
DISTANCE FROM LM	30 FT MINIMUM	PACED OFF	CREW/PAYLOAD TRADEOFF
DIRECTION FROM LM	IN FOV OF OTHER ASTRONAUT	EYEBALL	AVOID LM SHADOW ON SOLAR PANELS
DISTANCE FROM LRRR	10FT MINIMUM	PACED OFF	AVOID THERMAL INTERACTIONS
DIRECTION FROM LRRR	NOT DUE EAST OR WEST	EYEBALL	AVOID LRRR SHADOW ON SOLAR PANELS
SITE SELECTION	LEVEL, FREE FROM RUBBLE	EYEBALL	CONSTRAINS LEVELING CAPABILITY
LEVEL, WRT INDICATOR	$\pm$ 5°OF HORIZ	BALL LEVEL ON PSE	INTERACTS WITH ALIGNMENT
ALIGN, WRT INDICATOR	$\pm$ 5°OF E-W	GNOMON/ROSE ON PSE	POWER & ANTENNA REQUIREMENTS
READOUT OF ALIGNMENT	BETTER THAN $\pm$5°	GNOMON/ROSE ON PSE	PSE SCIENTIFIC DATA INTERPRETATION
NOTE THAT PSE HAS INTERNAL FINE LEVELING WITH $\pm$ 5° RANGE			

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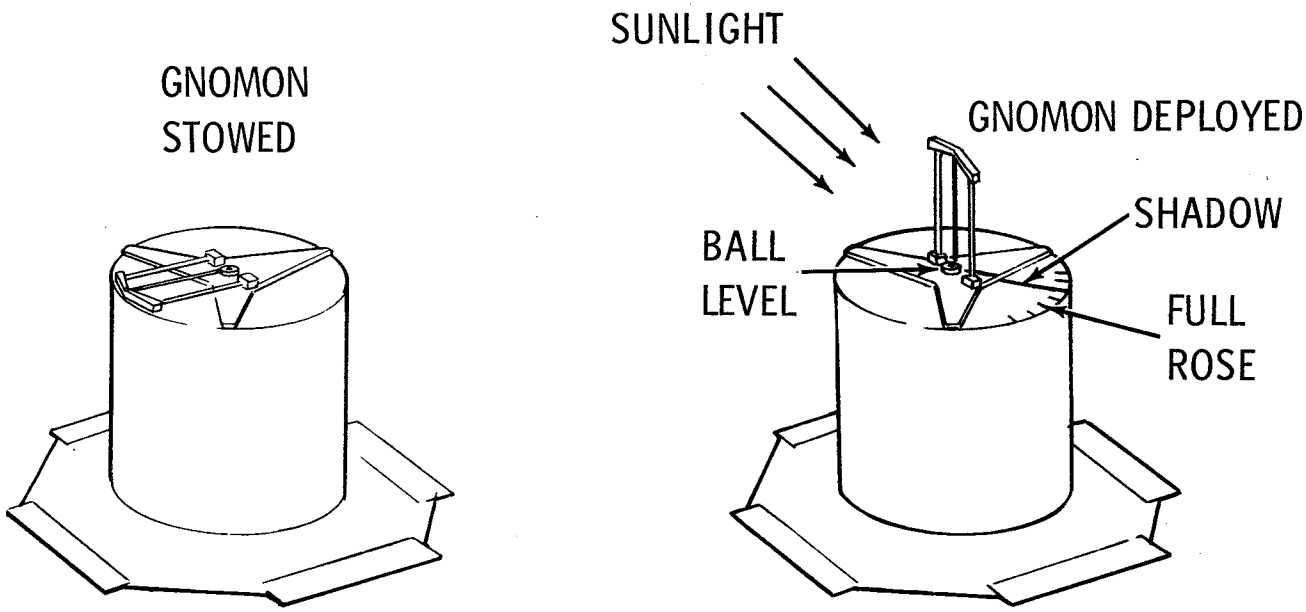
PSEP LEVEL AND ALIGNMENT INDICATORS



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STRUCTURE/THERMAL COMMANDS

OCTAL CMD NUMBER

027 DUST CELLS ON

CMD 027 IS A ONE-STATE CMD THAT ACTIVATES THE SOLAR CELL OUTPUTS (3) OF THE DUST DETECTOR.

031 DUST CELLS OFF

CMD 031 IS A ONE-STATE CMD THAT DEACTIVATES THE SOLAR CELL OUTPUTS (3) OF THE DUST DETECTOR.

NOTE THAT THERE IS EQUAL PROBABILITY OF THE DUST CELLS BEING ON OR OFF WHEN PSEP STARTS UP INITIALLY ON THE LUNAR SURFACE.

turns on or off power to pre-amps of cell voltages

STRUCTURE/THERMAL TELEMETRY

AT-03	THERM PLT 1 DEG F
AT-04	THERM PLT 2 DEG F
AT-05	THERM PLT 3 DEG F
AT-06	THERM PLT 4 DEG F
AT-07	THERM PLT 5 DEG F
AT-08	PRI/ST W1 DEG F
AT-09	PRI/ST W2 DEG F
AT-10	PRI/ST B1 DEG F
AT-11	PRI/ST W3 DEG F
AT-12	INSUL INT DEG F
AT-13	INSUL EXT DEG F

HK-83	AX-01	DUST CELL 1 DEG F
HK-30	AX-02	DUST CELL 2 DEG F
HK-56	AX-03	DUST CELL 3 DEG F
HK-84	AX-04	DUST 1 OUT MW/CM2
HK-26	AX-05	DUST 2 OUT MW/CM2
HK-41	AX-06	DUST 3 OUT MW/CM2

ALL PARAMETERS SAMPLED
ONCE PER 54 SEC PSEP
SEQUENCE

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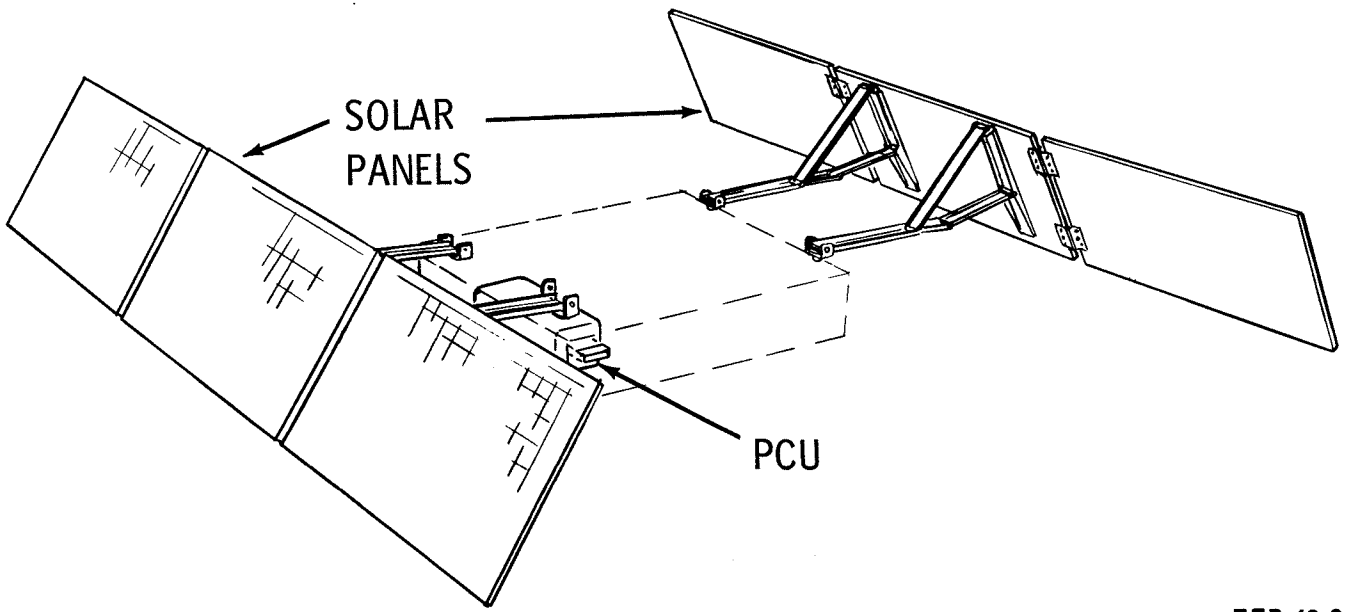
ELECTRICAL POWER SUBSYSTEM

- SOLAR PANEL ARRAY
- POWER CONDITIONING UNIT
- COMMANDS & TM DATA



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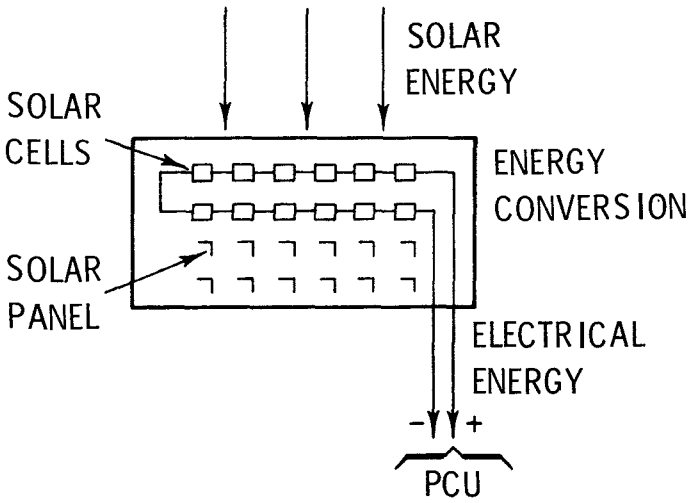
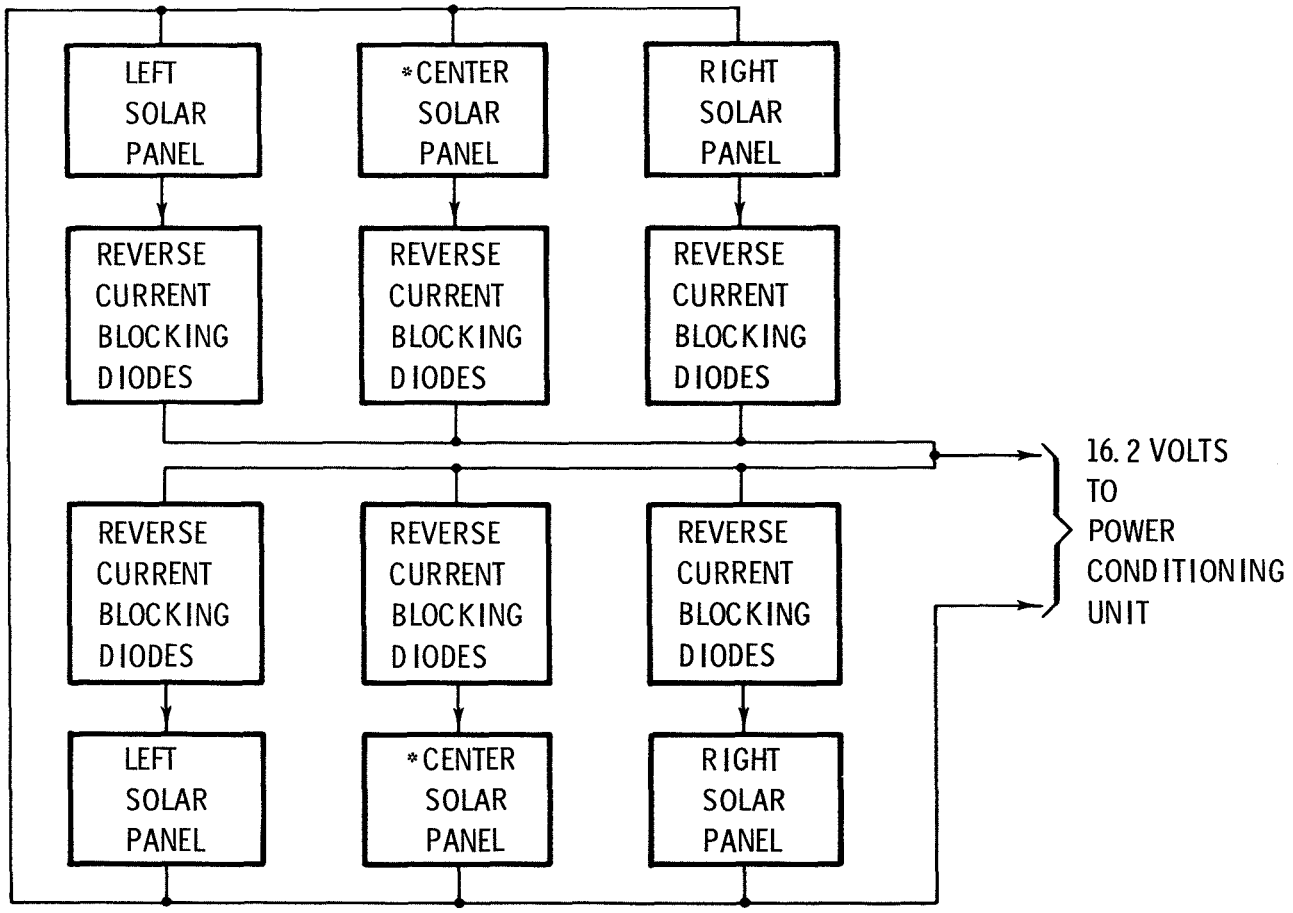
SOLAR PANEL



- SIX PANELS WITH IDENTICAL SOLAR CELL LAYOUTS
- 420 CELLS PER PANEL (TOTAL 2520)
- BLOCKING DIODES IN SERIES WITH EACH PANEL HAVE TRIPLE-PARALLEL REDUNDANCY
- TOTAL OUTPUT: 37 TO 43 WATTS AT 16.2 VDC
- CELLS ARE BLUE SENSITIVE, GRIDDED N-ON-P TYPE
- 0.006-IN. MICROSHEET COVER WITH BLUE FILTER DEPOSITED ON INNER FACE
- PANEL SIZE: 23.75 X 15.38 IN.
  TOTAL: 2.52 SQ FT/PANEL

SOLAR PANEL ARRAY FUNCTIONAL DIAGRAM



* THERMISTORS AT1 & AT2

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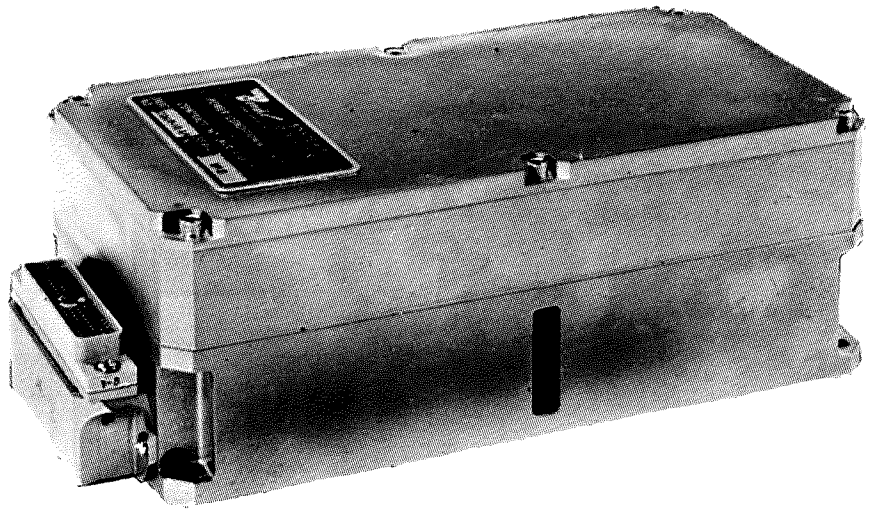
POWER CONDITIONING UNIT



SIZE - 8.36 X 4.14 X 2.94 IN.

WEIGHT - 4.5 POUNDS

PARTS COUNT -

TRANSISTORS	27	RELAY	1
DIODES	44	THERMISTORS	4
ZENER DIODES	4	INDUCTORS	11
CAPACITORS	71	TRANSFORMERS	8
RESISTORS	87		

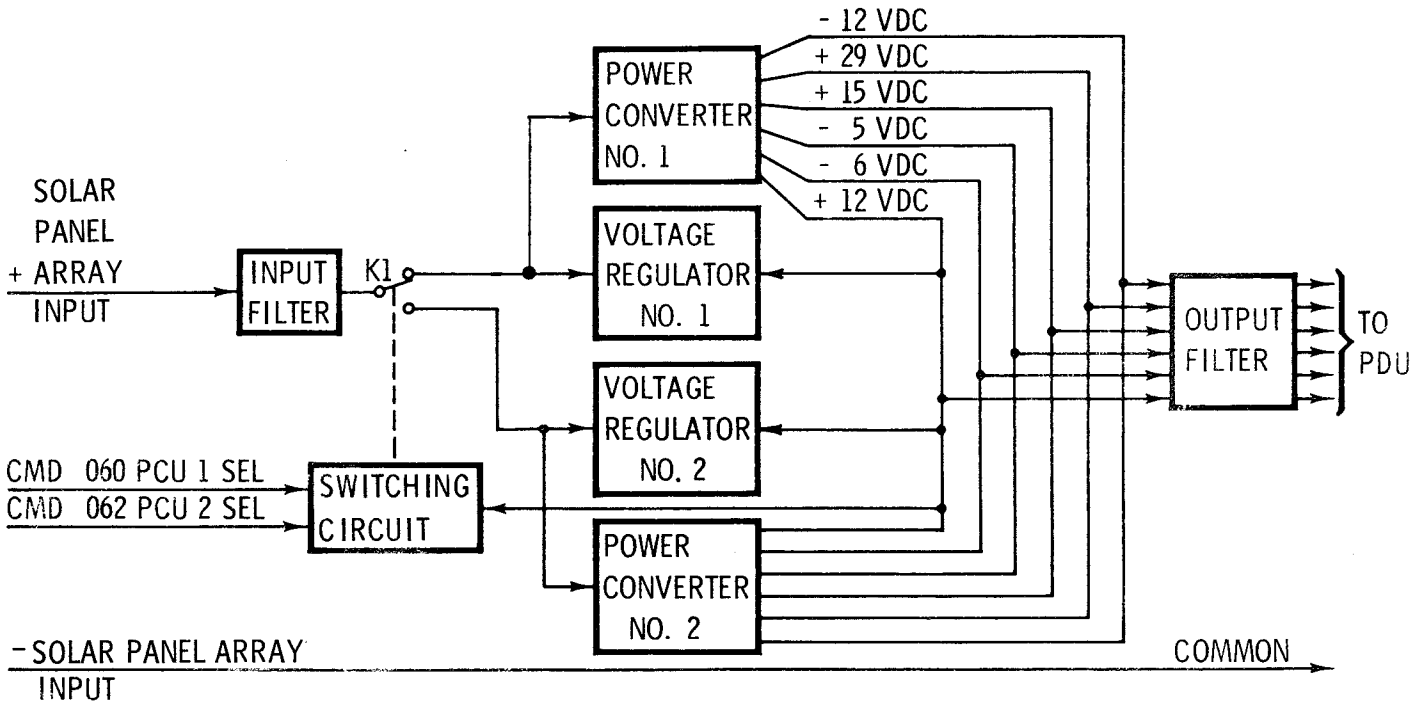
PACKAGING - SEVEN CORDWOOD MODULES ARE MOUNTED ON A "MOTHER BOARD". THERMAL REQUIREMENTS ARE MET BY USING MACHINED, GOLD-PLATED, MAGNESIUM CASES FOR THE MODULES.

CONNECTOR - HUGHES - 88 PIN.

PCU FEATURES

* CONSISTS OF REDUNDANT POWER CONDITIONERS WITH BOTH AUTOMATIC AND COMMANDABLE SELECTION OF THE STANDBY SECTION. OVER/UNDER VOLTAGES ARE SENSED FOR AUTOMATIC SWITCHING FROM PCU#1 TO PCU#2.
* PROVIDES 6 REGULATED DC OUTPUT VOLTAGES WITH NOMINAL VALUES OF +29, +15, +12, +5, -6, AND -12 VOLTS.
* CONTAINS FILTERS TO LIMIT OUTPUT RIPPLE VOLTAGE TO BE APPROXIMATELY 150 MILLIVOLTS PEAK-TO-PEAK.
* PROVIDES TM SIGNALS FOR MONITORING SOLAR PANEL INPUT CURRENT, SOLAR PANEL INPUT VOLTAGE, SHUNT REGULATOR CURRENT AND PCU TEMPERATURES.
* PROVIDES RESERVE POWER REFERENCE AND RESERVE POWER LEVEL SIGNALS TO RIPPLE-OFF CIRCUITS IN THE PDU.

SIMPLIFIED BLOCK DIAGRAM - PCU



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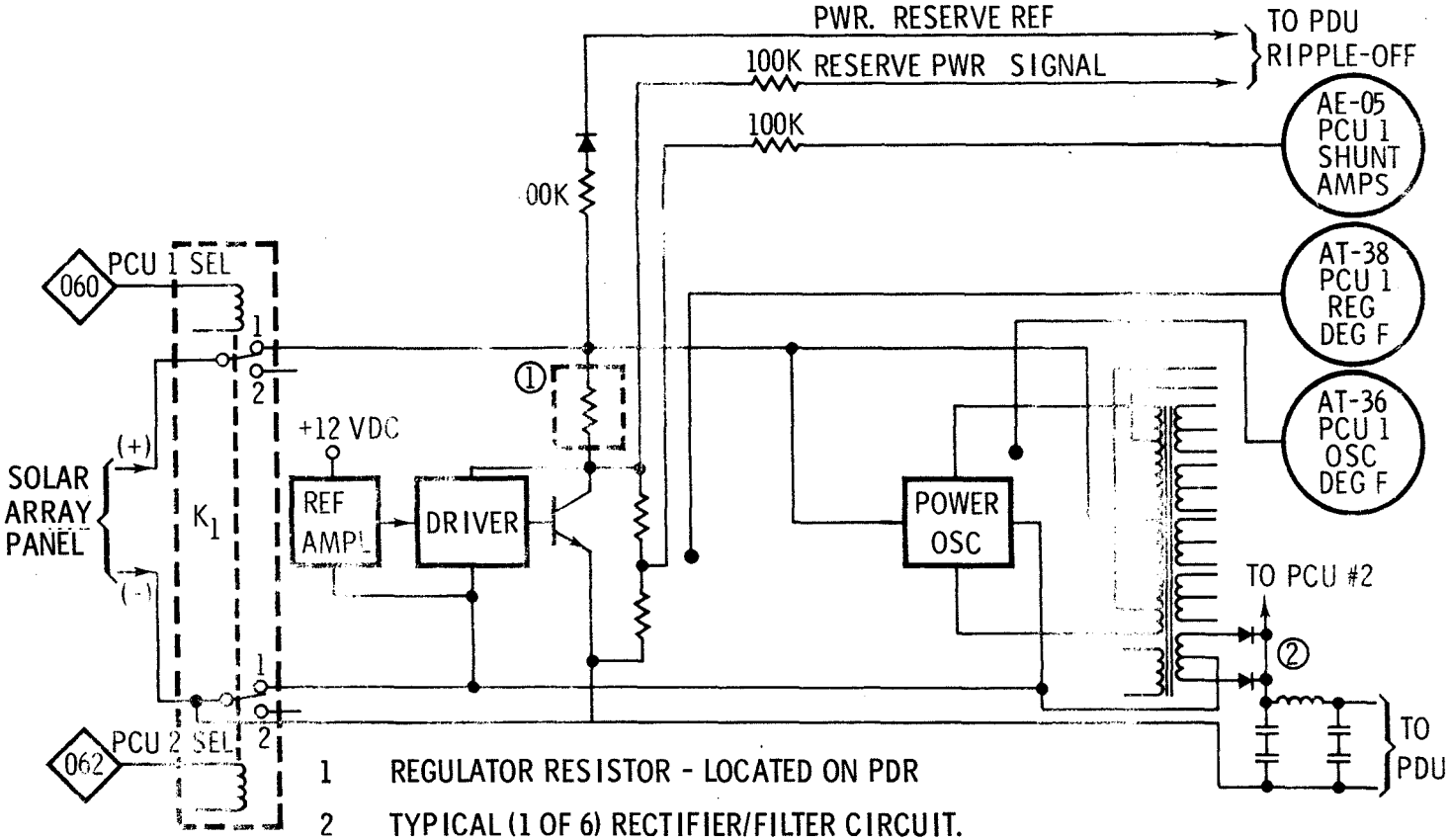
PCU 1 DIAGRAM



1 REGULATOR RESISTOR - LOCATED ON PDR

2 TYPICAL (1 OF 6) RECTIFIER/FILTER CIRCUIT. FILTER IS COMMON TO BOTH PC#1 & PC#2.

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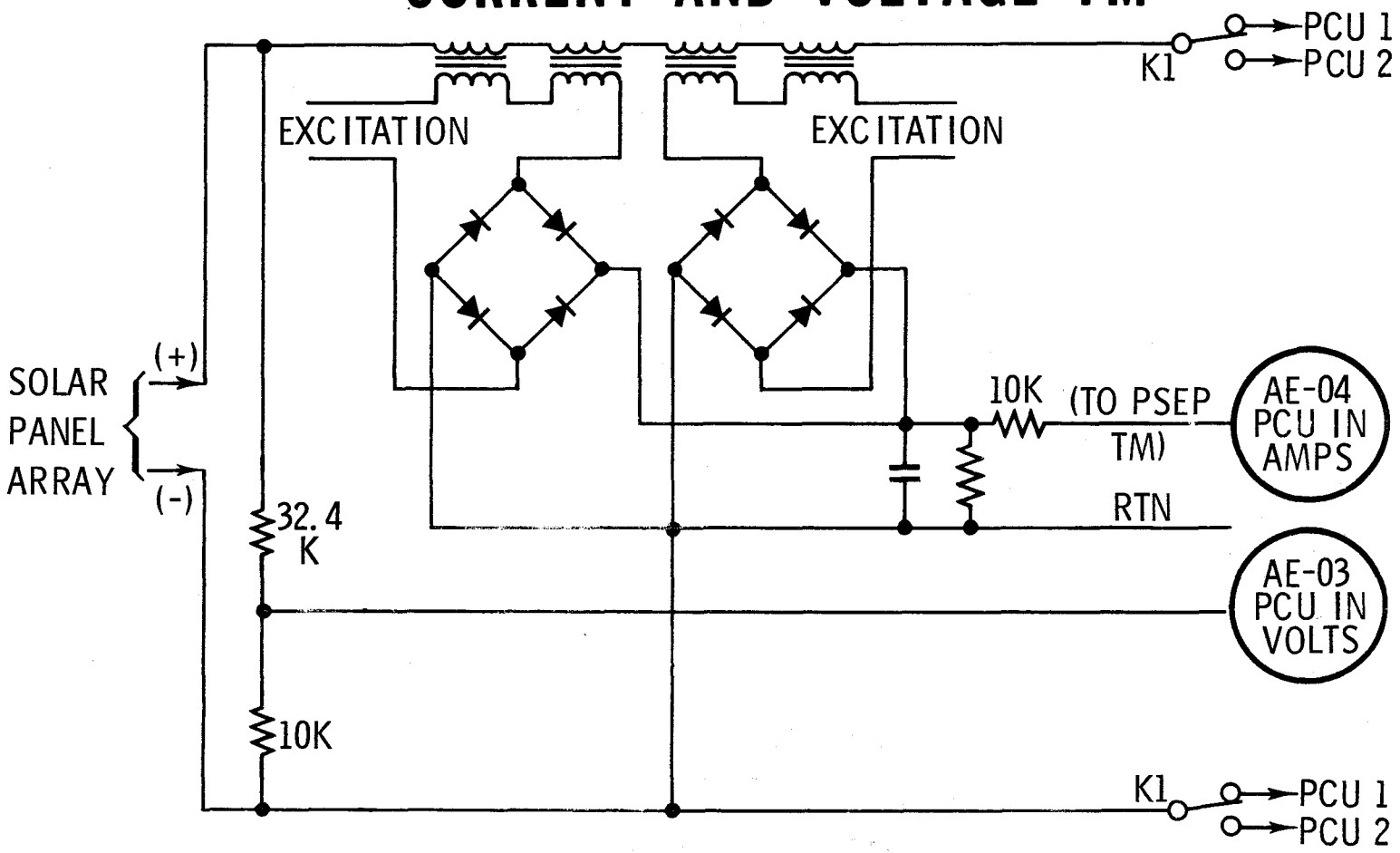
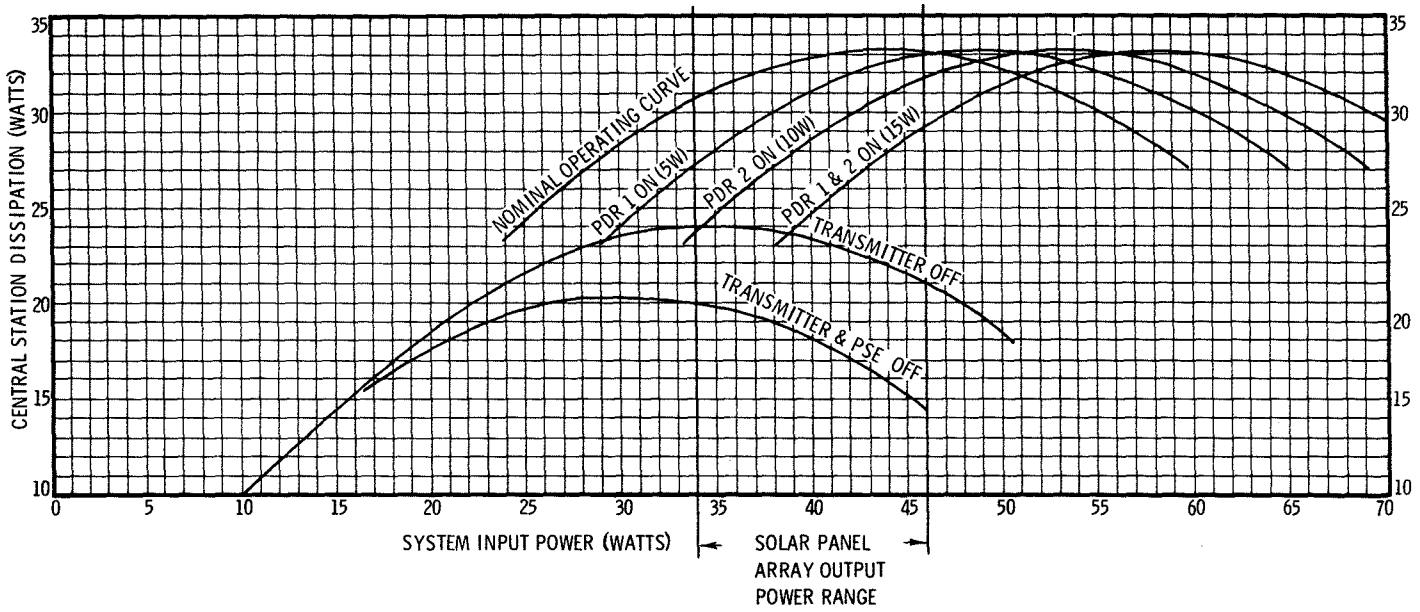
CURRENT AND VOLTAGE TM



FEB 69 2601 6.8

PCU POWER/THERMAL RELATIONSHIP



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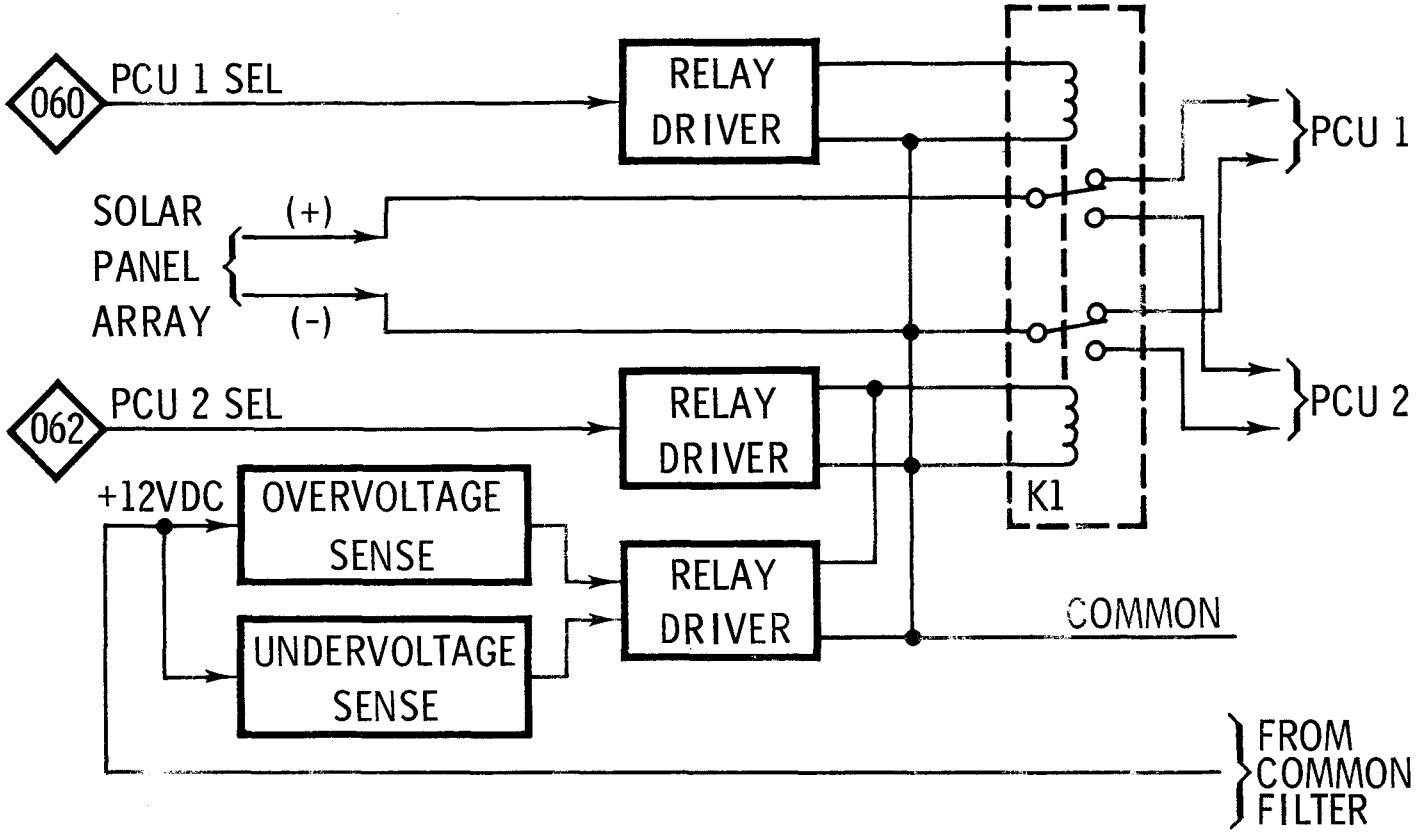
PCU SELECTION FUNCTION



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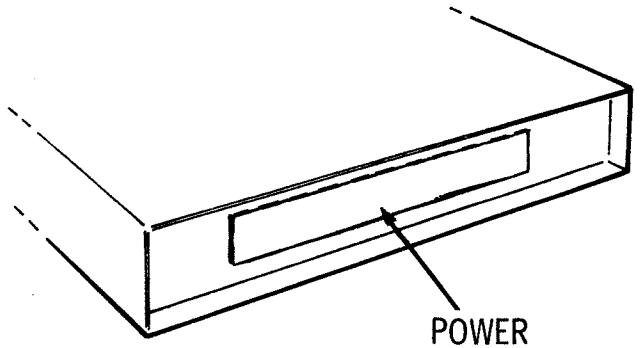
POWER DISSIPATION MODULE (PDM)

- PART OF POWER MANAGEMENT PROVISIONS
- MOUNTED EXTERNAL TO PRIMARY STRUCTURE
- CHARACTERISTICS:



RESISTANCE ID	NETWORK RESISTANCE	NUMBER OF RESISTORS	DISSIPATION IN RESISTORS
PCU 1 REGULATOR	6Ω	6	30 WATTS (MAX)
PCU 2 REGULATOR	6Ω	8	30 WATTS (MAX)
PDR 1	170Ω	2	5 WATTS (29 V BUS)
PDR 2	85Ω	4	10 WATTS (29 V BUS)

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EPS DATA

FROM SOLAR PANEL ARRAY	FROM PCU	FROM PDU
AT-01 SOLAR PNL 1 DEG F	AT-36 PCU 1 OSC DEG F	AE-07 PCU + 29V OUT
AT-02 SOLAR PNL 2 DEG F	AT-37 PCU 2 OSC DEG F	AE-08 PCU + 15V OUT
	AT-38 PCU 1 REG DEG F	AE-09 PCU + 12V OUT
	AT-39 PCU 2 REG DEG F	AE-10 PCU + 5V OUT
	AE-03 PCU IN VOLTS	AE-11 PCU - 12V OUT
	AE-04 PCU IN AMPS	AE-12 PCU - 6V OUT
	AE-05 PCU 1 SHUNT AMPS	AB-04 EXP 1/2 STBY STA
	AE-06 PCU 2 SHUNT AMPS	AB-05 EXP 345 STBY STA

EPS COMMANDS

OCTAL CMD NUMBERS

•017 DISSIP R1 ON

THIS CMD ACTUATES RELAY K-16, IN THE PDU, TO THE POSITION THAT APPLIES +29 VDC TO A 5-WATT POWER DISSIPATION RESISTOR, AND IS USED TO OPTIMIZE THE SYSTEM THERMAL BALANCE.

•021 DISSIP R1 OFF

THIS CMD ACTUATES RELAY K-16, IN THE PDU, TO THE POSITION THAT REMOVES +29 VDC FROM THE 5-WATT POWER DISSIPATION RESISTOR.

•022 DISSIP R2 ON

THIS CMD ACTUATES RELAY K-17, IN THE PDU, TO THE POSITION THAT APPLIES +29 VDC TO A 10-WATT POWER DISSIPATION RESISTOR, AND IS USED TO OPTIMIZE THE SYSTEM THERMAL BALANCE.

•023 DISSIP R2 OFF

THIS CMD ACTUATES RELAY K-17, IN THE PDU, TO THE POSITION THAT REMOVES +29 VDC FROM THE 10-WATT POWER DISSIPATION RESISTOR.

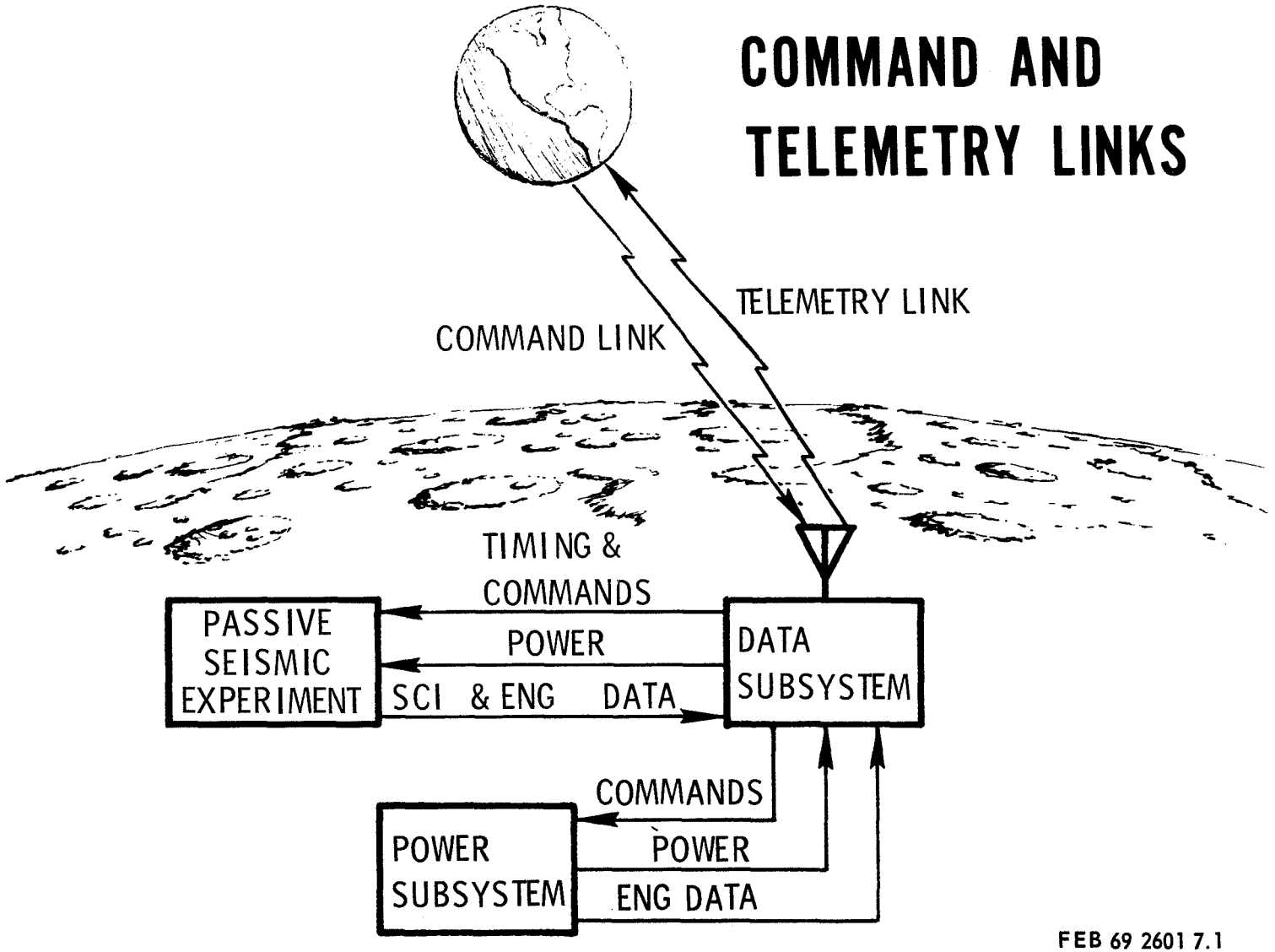
•060 PCU 1 SEL

THIS CMD ACTUATES RELAY K-01, IN THE PCU, WHICH APPLIES +16 VDC FROM THE SOLAR PANEL ARRAY TO PCU 1 AND SIMULTANEOUSLY DEENERGIZES PCU 2. PCU 1 IS PRESET TO BE ENERGIZED AT INITIAL LUNAR ACTIVATION. NOTE THAT THERE IS AN AUTOMATIC SWITCH-OVER FEATURE TO PCU 2 IN THE EVENT THE +12 VDC BUS VARIES MORE THAN ± 1 VDC. ADDING OR REMOVING ELECTRICAL LOADS (VIA GROUND COMMANDS) ON PCU 1 CAN PREVENT THE +12 VDC BUS FROM VARYING OUT OF LIMITS. IN THE EVENT AUTOMATIC SWITCH-OVER TO PCU 2 HAS OCCURRED, THIS COMMAND MUST BE FLAGGED AS HIGHLY CRITICAL. THE CAUSE OF THE SWITCH-OVER MUST BE DETERMINED BEFORE THIS COMMAND IS EXECUTED.

•062 PCU 2 SEL

THIS CMD ACTUATES RELAY K-01, IN THE PCU, WHICH APPLIES +16 VDC FROM THE SOLAR PANEL ARRAY TO PCU 2 AND SIMULTANEOUSLY DEENERGIZES PCU 1. NOTE THAT AT THE TIME OF LUNAR ACTIVATION, PCU 2 IS DEENERGIZED, WITH NO MEANS TO DETERMINE ITS CONDITION. FURTHER NOTE THAT THERE IS NO AUTOMATIC SWITCH-OVER FROM PCU 2 TO PCU 1. THIS SITUATION, THEREFORE, MAKES THIS COMMAND HIGHLY CRITICAL. THIS COMMAND SHOULD BE EXECUTED ONLY AFTER DETERMINING THAT PCU 1 IS ON THE VERGE OF FAILING.

COMMAND AND TELEMETRY LINKS



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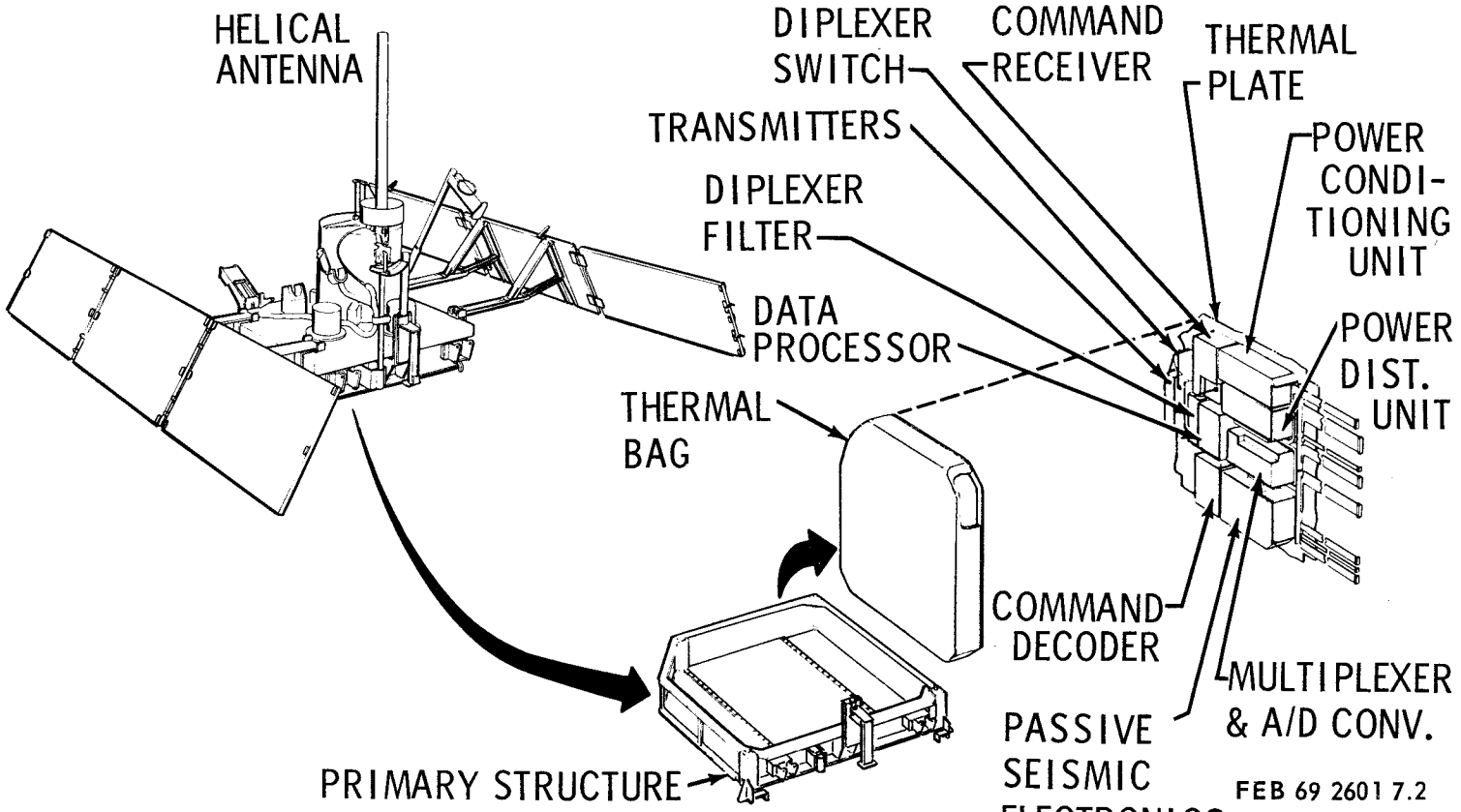
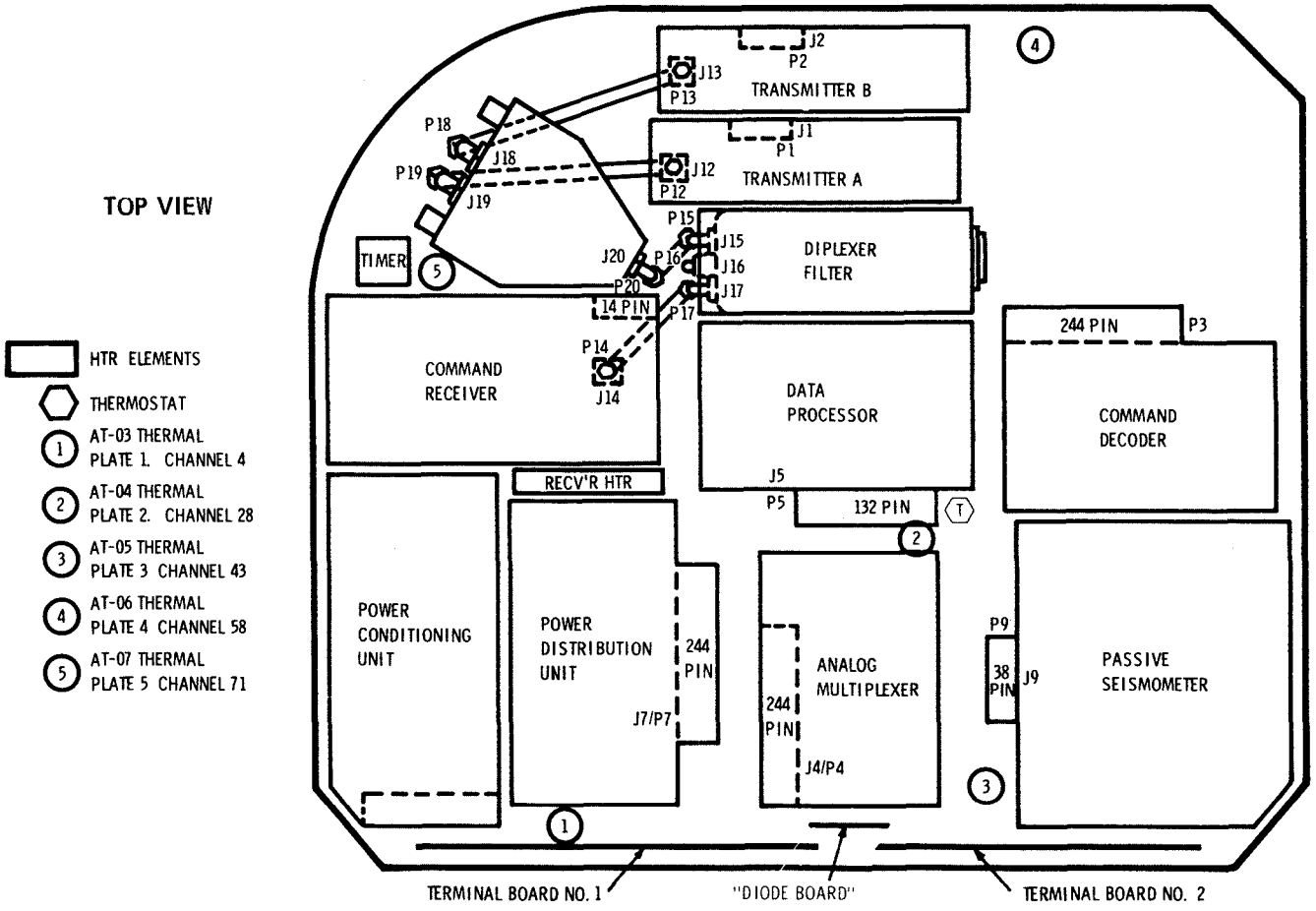
CENTRAL STATION
DATA SUBSYSTEM COMPONENTS



CENTRAL STATION SENSORS AND HEATERS

TOP VIEW



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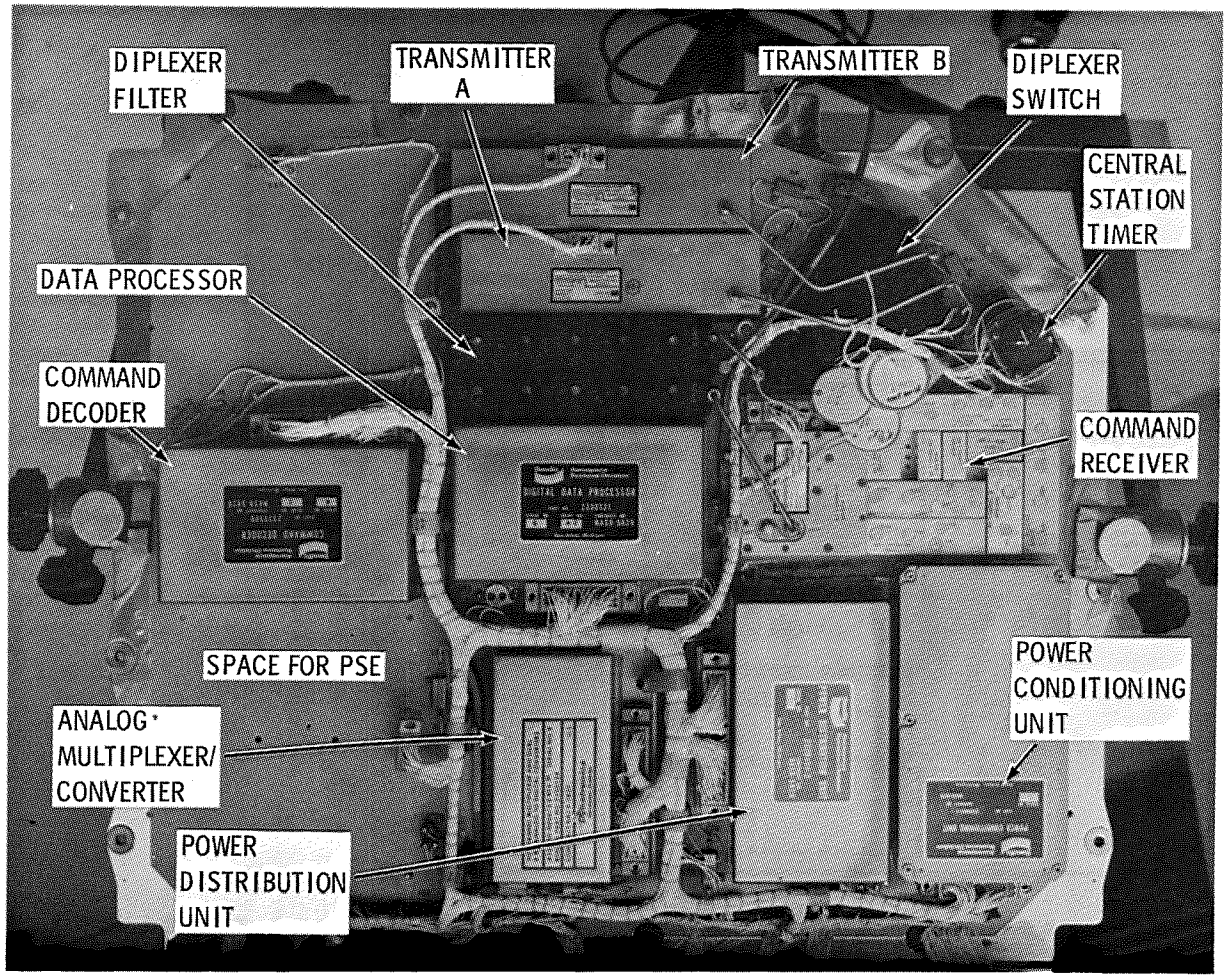
CENTRAL STATION LAYOUT

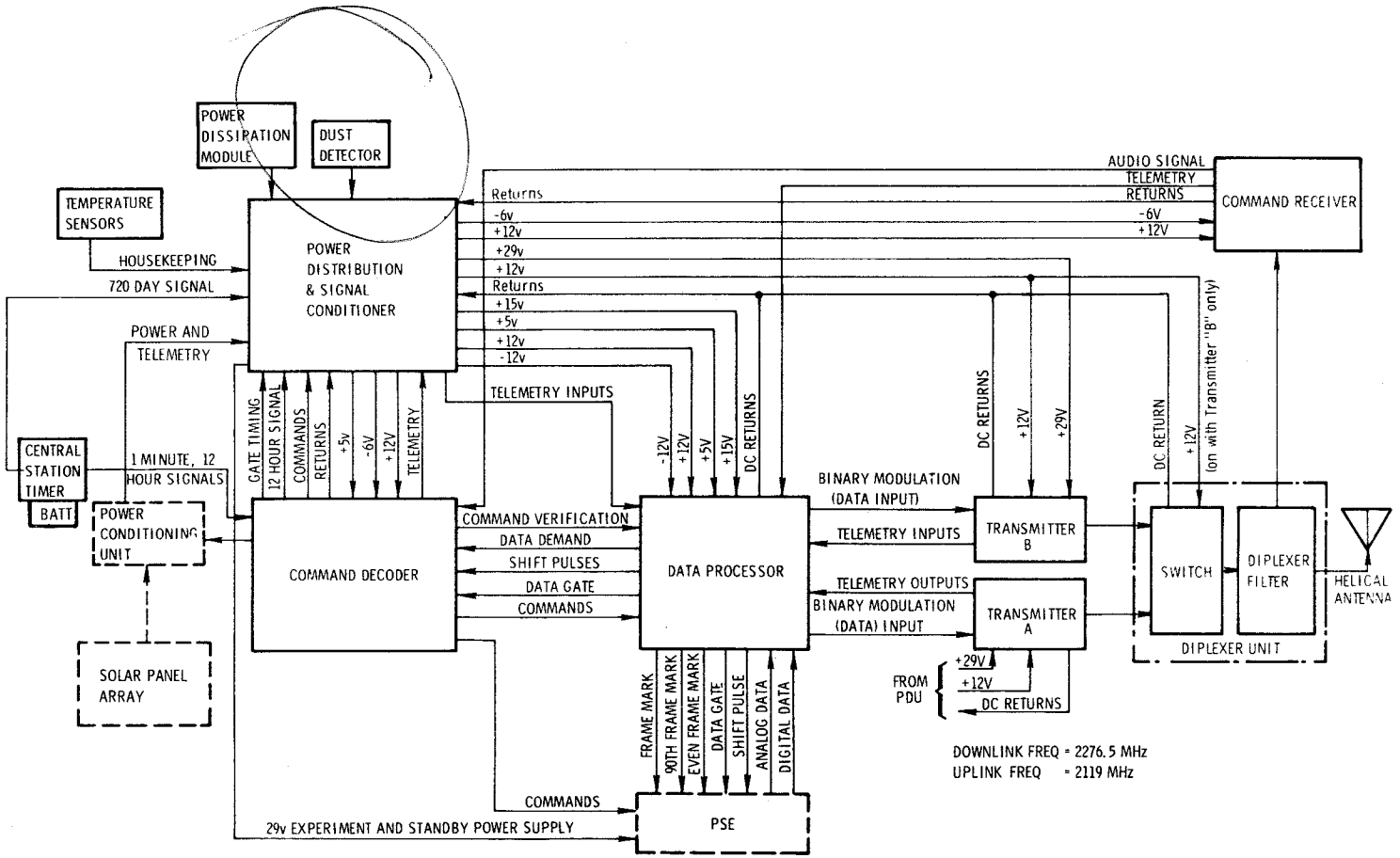


FEB 69 26017.4

DATA SUBSYSTEM HARDWARE

ITEM	FUNCTION
(A) POWER DISTRIBUTION & SIGNAL CONDITIONER	CONTROL OF POWER SWITCHING AS COMMANDED AND CONDITIONING OF ENGINEERING STATUS DATA
(B) COMMAND DECODER	DECODE RECEIVED SIGNAL & ISSUE COMMANDS TO THE SYSTEM.
(C) DATA PROCESSOR	COLLECT AND FORMAT SCIENTIFIC OUTPUTS FROM THE PSE. COLLECT AND CONVERT ANALOG HOUSEKEEPING DATA INTO DIGITAL FORM.
(D) COMMAND RECEIVER	ACCEPT THE EARTH-TO-MOON UPLINK SIGNAL.
(E) TRANSMITTER	GENERATE MOON-TO-EARTH DOWNLINK SIGNAL
(F) DIPLEXER SWITCH	CONNECT EITHER TRANSMITTER TO THE ANTENNA.
(G) DIPLEXER FILTER	CONNECT RECEIVER INPUT AND TRANSMITTER OUTPUT TO THE ANTENNA WITH REQUIRED RECEIVER/ TRANSMITTER ISOLATION.
(H) CENTRAL STATION TIMER	PROVIDE AUTOMATIC ACTIVATION FEATURES (AS A BACK-UP) AND SWITCH OFF TRANSMITTERS AFTER PRE-SET INTERVAL
(I) ANTENNA	RECEIVE AND RADIATE UP-AND-DOWN LINK RF SIGNALS.
(J) ANTENNA POSITIONING MECHANISM	MEANS OF ANTENNA ALIGNMENT.
(K) TEMPERATURE SENSORS	SUPPLY TEMPERATURE DATA OF SELECTED POINTS AROUND THE CENTRAL STATION

DATA SUBSYSTEM BLOCK DIAGRAM



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SUMMARY OF DATA S/S COMPONENTS

COMPONENT	VOLTAGE/POWER* REQUIREMENTS		TOTAL POWER	SIZE	WEIGHT	RELIABILITY
POWER DISTRIBUTION UNIT	+29V	375 mw	1753 mw	2.8x4.0x7.25	2.29 lbs	0.94484
	+15V	75 mw				
	±12V	735 mw				
	± 5V	85 mw				
	- 6V	8 mw				
	-12V	475 mw				
COMMAND DECODER	+12V	325 mw	1330 mw	2.8x3.94x6.25	2.68 lbs	0.98304
	± 5V	775 mw				
	- 6V	230 mw				
DATA PROCESSOR	+12V	50 mw	500 mw	2.8x3.94x6.25	2.64 lbs	0.95863
	+ 5V	450 mw				
MULTIPLEXER	+15V	65 mw	1435 mw	2.62x4.23x5.92	1.89 lbs	
	±12V	150 mw				
	± 5V	1100 mw				
	-12V	120 mw				
TRANSMITTER (EACH)	+29V	8000 mw	8500 mw	1.5x2.0x7.5	1.17 lbs	0.9796
	+12V	500 mw				
RECEIVER	+12V	665 mw	695 mw	1.5x4.0x8.0	3.01lbs**	0.98888
	- 6V	30 mw				
DIPLEXER SWITCH	+12V	150 mw	150 mw	2.1x4.0x4.5	1.31 lbs	0.9997
DIPLEXER FILTER	–	–	–	2.5x2.5x7.0		0.9989
ANTENNA	–	–	–	1.5x23+ GND PL	1.05 lbs	–
CENT STA TIMER	BATTERY		–	1.32x1.32x2.63	.036 lbs	–
HARNESS ASSY (INCLUDES PCB's CONNECTORS & SWITCHES)					2.92 lbs	–
TOTAL POWER AND WEIGHT			14.345 w		20.49lbs	

*MEASURED POWER AT ROOM TEMPERATURE

** INCLUDES DIPLEXER FILTER

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PSEP COMMAND LINK

* ANTENNA
  * DIPLEXER
    * COMMAND RECEIVER
      * COMMAND DECODER

COMMAND LINK CHARACTERISTICS

FUNCTION/PARAMETER	PSEP	MSFN
1. FREQUENCY	2119 ± 0.001% MHz	2119 MHz
2. MODULATION	–	PM, ± 3 RADIANS
3. MODULATING SIGNAL	–	1 KHz SINE WAVE SYNC SIGNAL LINEARLY ADDED TO A 2 KHz SUBCARRIER.
4. DATA RATE		1000 bps
5. IF BANDWIDTH (3 db)	275 ± 25 KHz	–
6. RECEIVER DYNAMIC RANGE	- 101 TO - 61 dbm	–
7. PERMISSIBLE Pe (PROBABILITY OF BIT ERROR)	10^{-9}	
8. REQUIRED PREDETECTION S/N FOR 10^{-9} BER	+ 12 db	
9. S/N MARGIN FOR Pe of 10^{-9} (30' ANTENNA)	NOMINAL +32 db WORST CASE +28 db	

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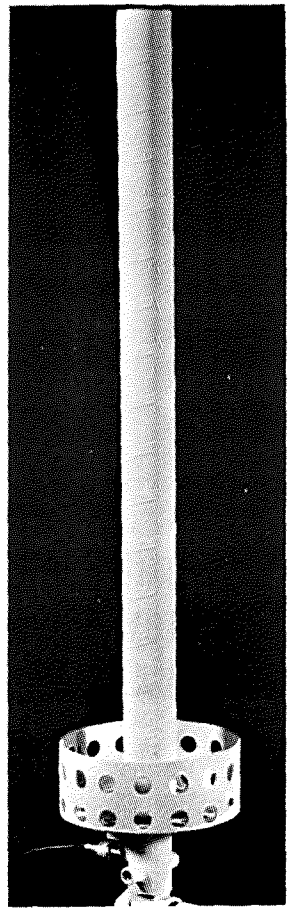
ANTENNA DESCRIPTION

* FLAT "RIBBON-LIKE" COPPER CONDUCTOR WRAPPED AROUND FIBERGLASS-EPOXY TUBE.
* 1 1/2 INCHES IN DIAMETER AND 23 INCHES LONG.
* USES 5" GROUND PLANE WITH A 2" CYLINDRICAL SKIRT
* IMPEDANCE MATCHING TRANSFORMER AT ANTENNA FEED POINT MATCHES THE ANTENNA IMPEDANCE TO A 50 OHM COAXIAL LINE.
* MOUNTED ON POSITIONING MECHANISM FOR QUICK ALIGNMENT BY CREWMAN.
* COATED WITH WHITE REFLECTING THERMAL PAINT.
* WEIGHT - 1.28 POUNDS INCLUDING CONNECTOR AND CABLE.



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ANTENNA CHARACTERISTICS

	TRANSMIT		RECEIVE	
	SPEC	MEAS	SPEC	MEAS
GAIN				
ON BORESIGHT	15.2 db	16.0 db	14.7 db	15.2 db
BEAMWIDTH AT 11.0 db GAIN			27°	36°
BEAMWIDTH AT 11.5 db GAIN	27°	33°		
AXIAL RATIO	3 db	1.3 db	3 db	1.0 db
INPUT VSWR	1.25 : 1	1.20 : 1	1.5 : 1	1.20 : 1
SIDELOBE LEVEL	-10 db	-11 db	-10 db	11.3 db
WEIGHT (ACTUAL)	1.28 LBs (including cable)			

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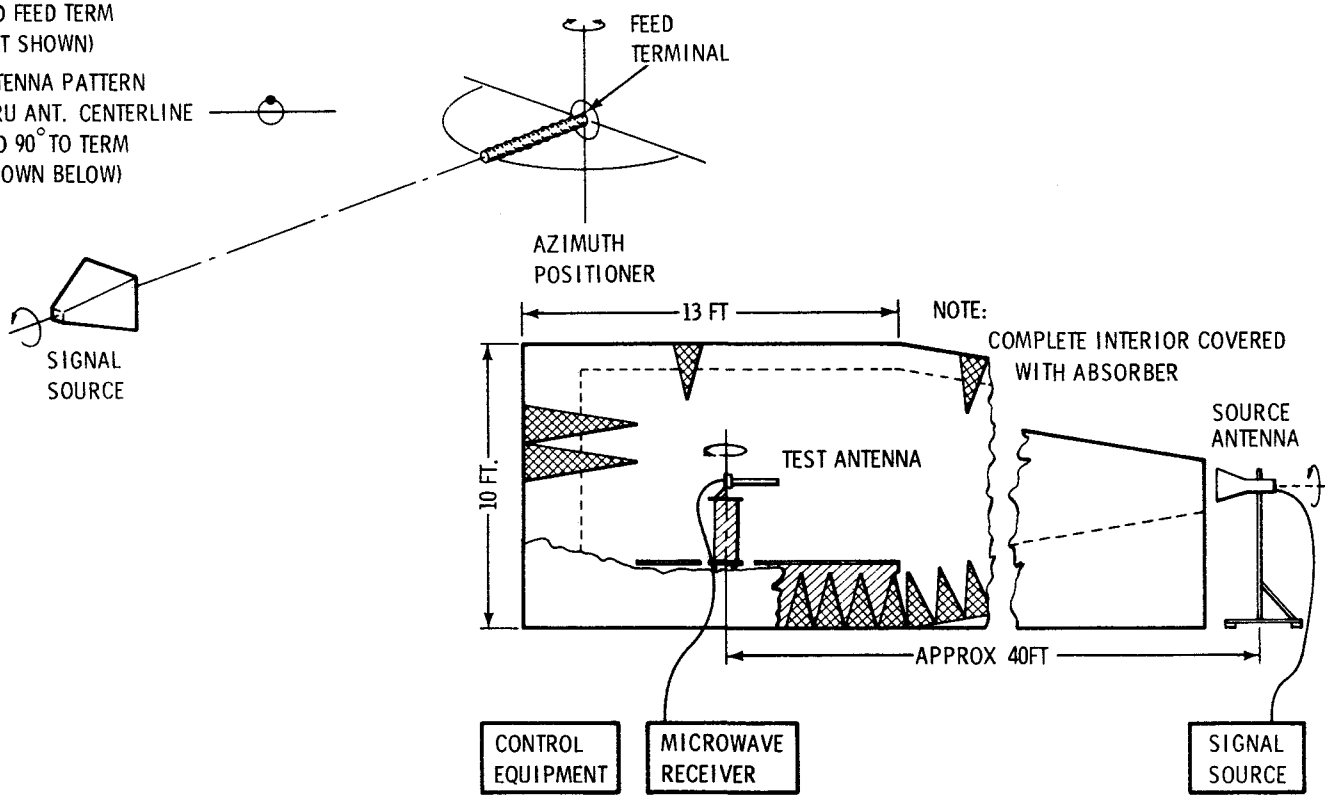
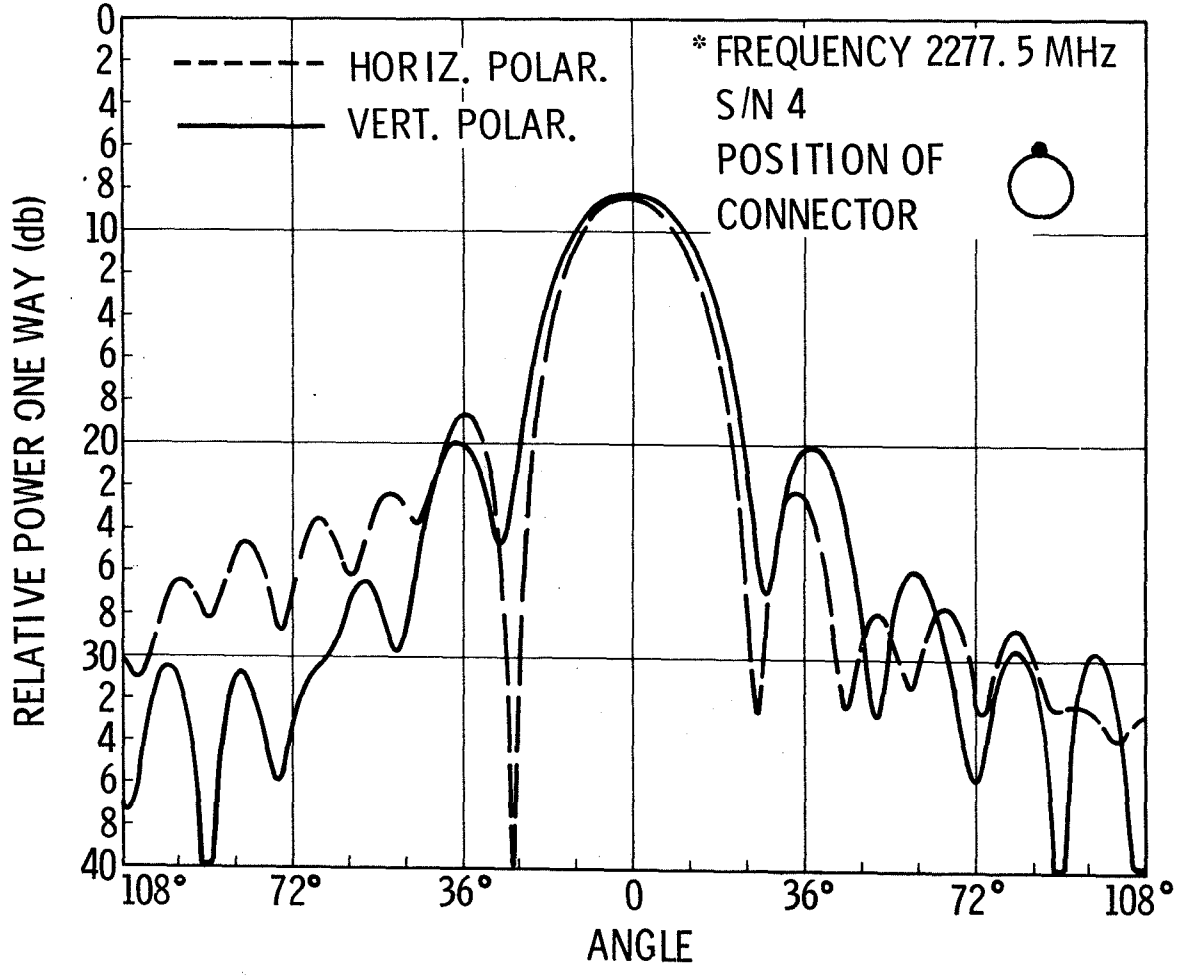
ANTENNA TEST

1. ANTENNA PATTERN THRU ANT CENTERLINE AND FEED TERM (NOT SHOWN)
2. ANTENNA PATTERN THRU ANT. CENTERLINE AND 90° TO TERM (SHOWN BELOW)



FEB 69 2601 7.12

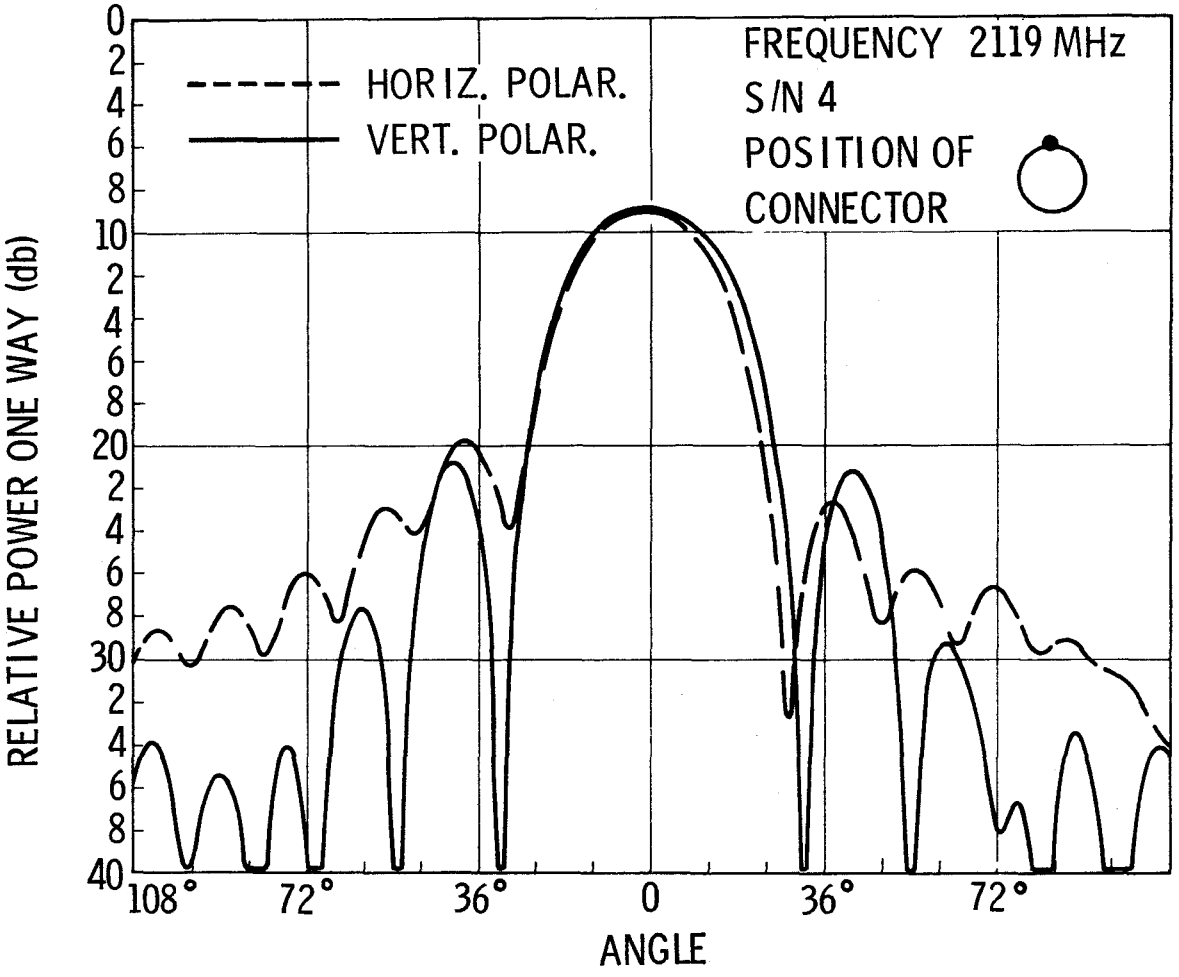
ANTENNA PATTERN (DOWNLINK)



* TEST FREQUENCY — NOT NECESSARILY EASEP.

FEB 69 2601 7.13

ANTENNA PATTERN (UPLINK)

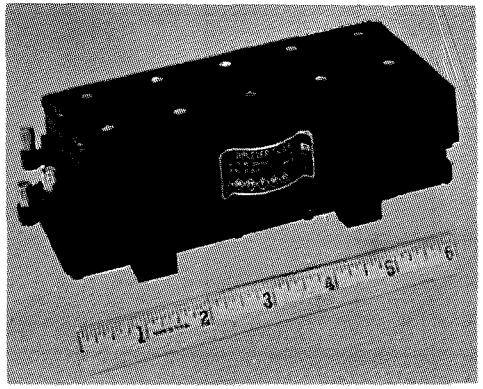


FEB 69 7.14

DIPLEXER FILTER

* PROVIDES TRANSMITTER/RECEIVER ISOLATION WITH A COMMON ANTENNA
* USES TUNEABLE CAVITY BANDPASS FILTERS - 5 IN TRANSMIT AND 5 IN RECEIVE PATH.
* CHARACTERISTICS

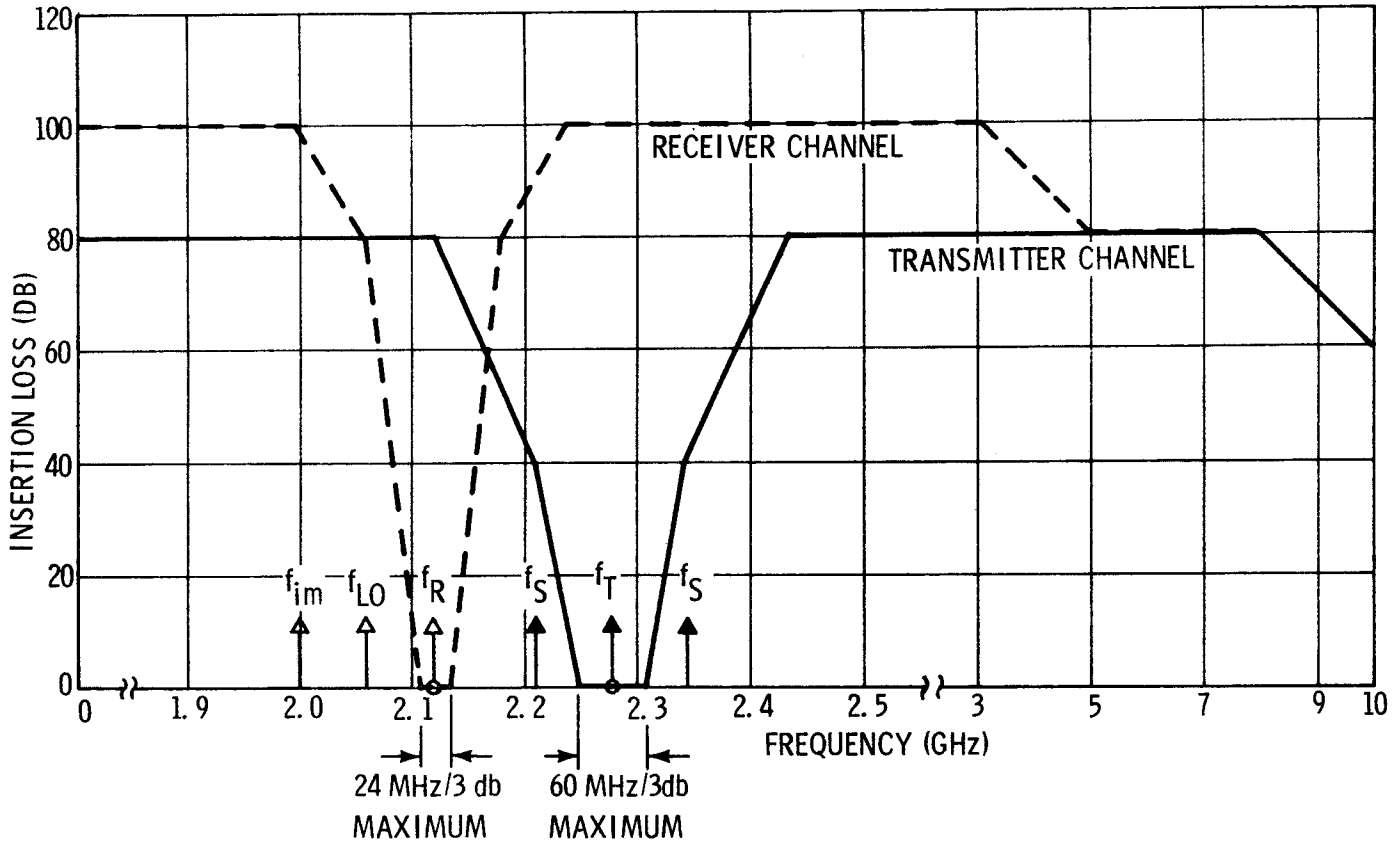
RECEIVER PATH	MEAS.	SPEC
INSERTION LOSS	1.30 db	2.5 db
VSWR	1.10:1	1.36:1
CENTER FREQUENCY:	2119	2118-2120 MHz
MAX 3 db BANDWIDTH	11.0 MHz	24 MHz
MIN 3 db BANDWIDTH	11.0 MHz	2.18 MHz
TRANSMITTER PATH		
INSERTION LOSS:	0.70 db	0.8 db
VSWR	1.10:1	1.36:1
CENTER FREQUENCY	2275-2280 MHz	2275-2280 MHz
MAX 3 db BANDWIDTH	45 MHz	60 MHz
MIN 3 db BANDWIDTH	45 MHz	5.35 MHz
POWER HANDLING CAPABILITY	20.0 WATTS	1.5 WATTS



* MISCELLANEOUS
  - DIMENSIONS - 2.5 x 2.5 x 6.88 INCHES
  - WEIGHT - 0.9 POUNDS

FEB 69 2601 7.15

DIPLEXER FILTER
MINIMUM REJECTION REQUIREMENTS



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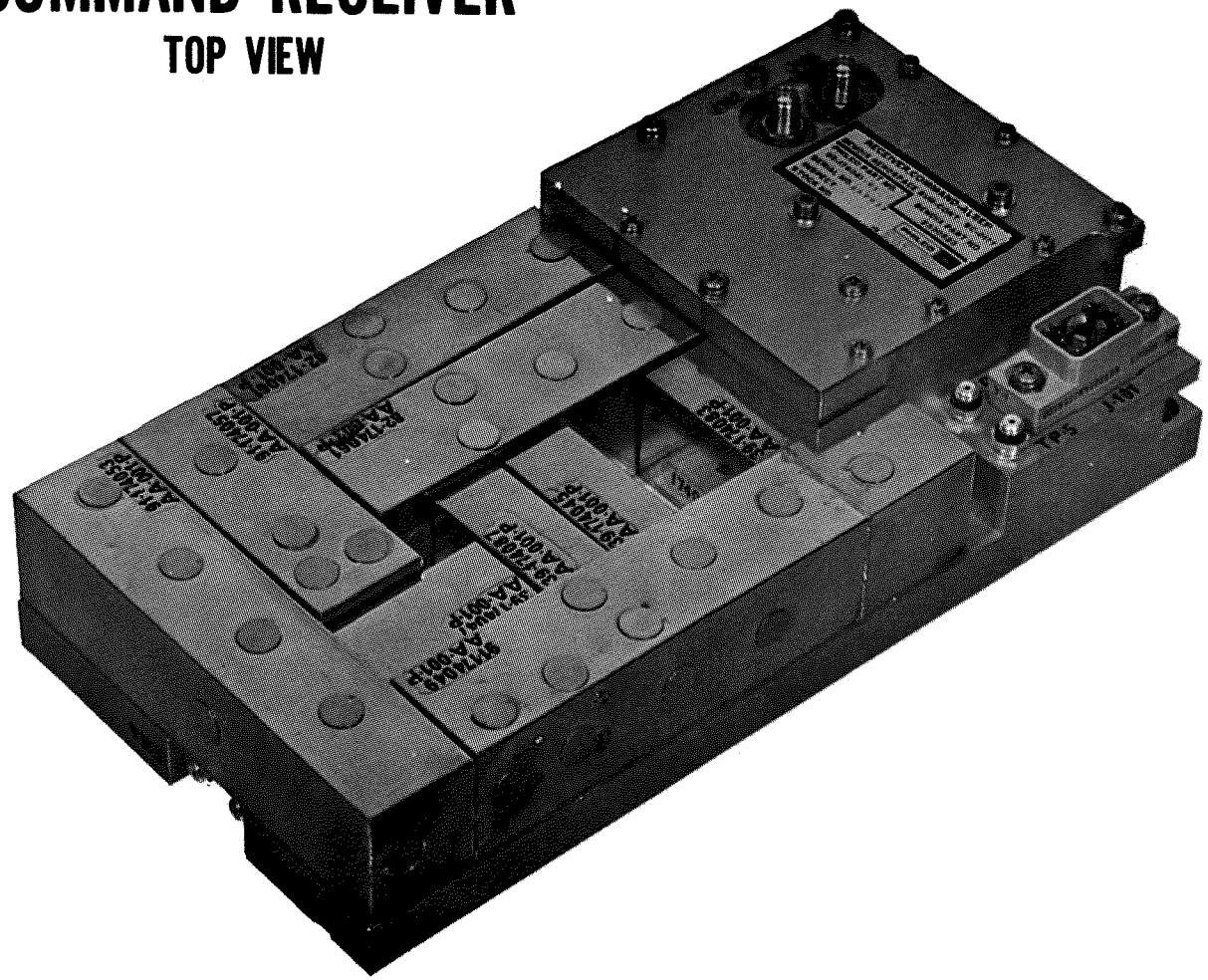
COMMAND RECEIVER

TOP VIEW



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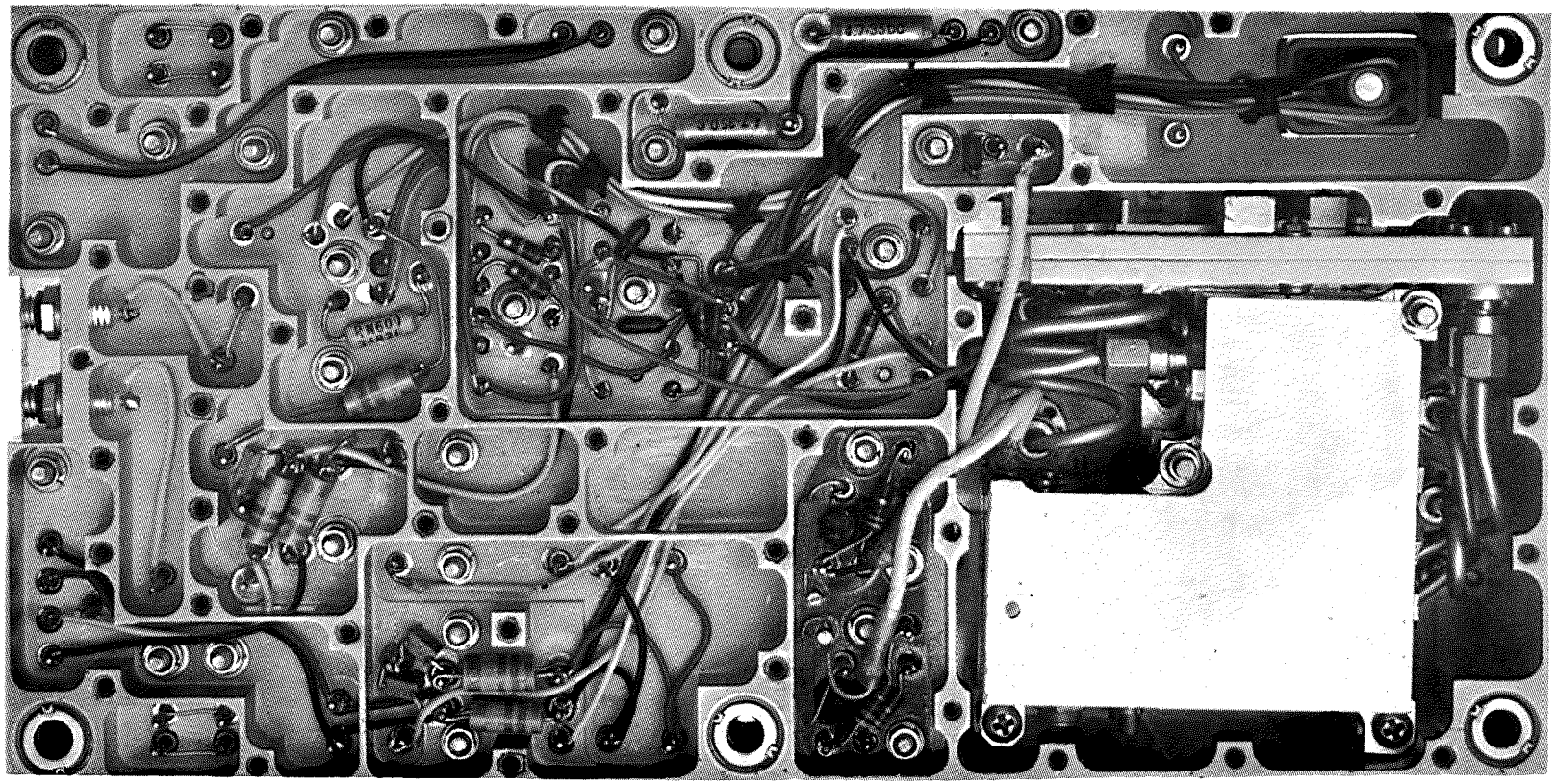
COMMAND RECEIVER

BOTTOM VIEW

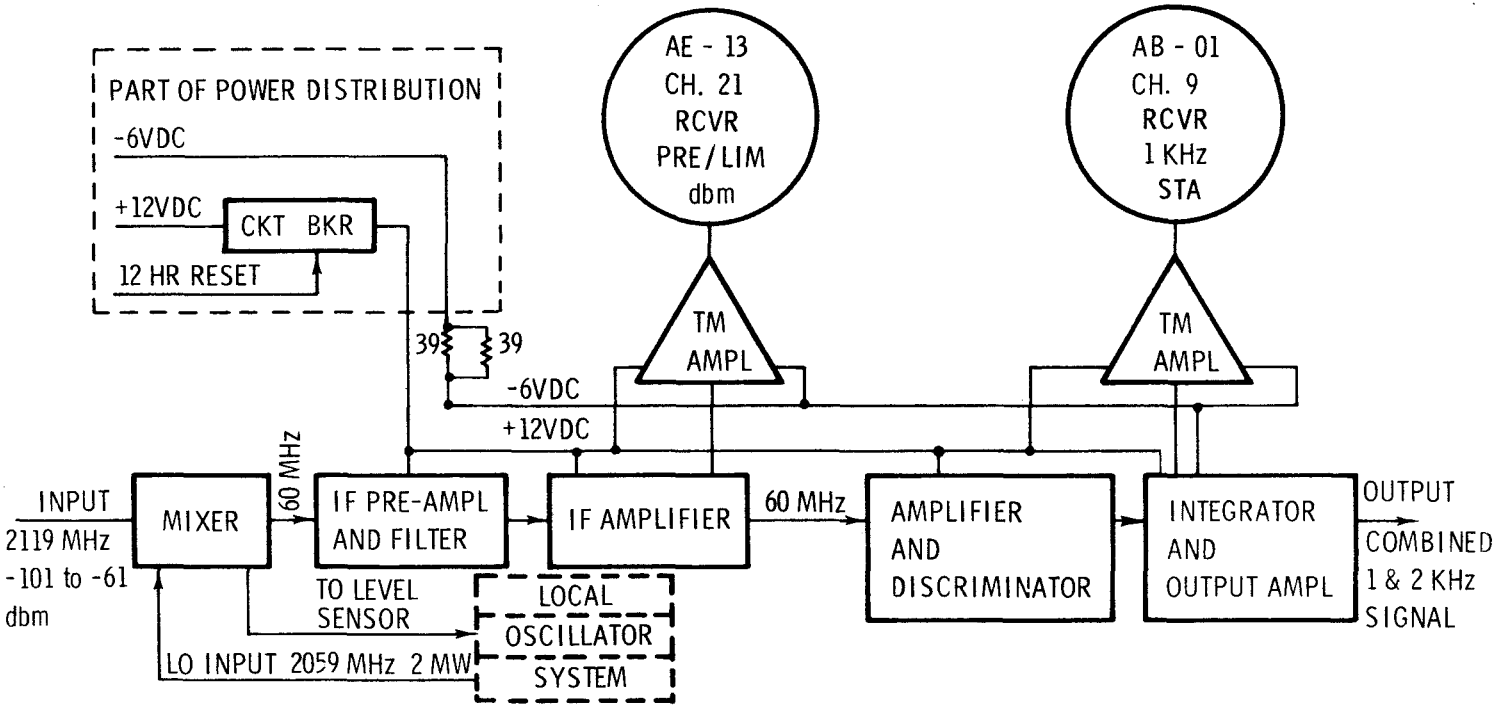


FEB 69 2601 7.18

COMMAND RECEIVER

* RECEIVES SIGNALS FROM THE MSFN STATIONS ON A FREQUENCY OF 2119 MHz.
* LOW SIDE LOCAL OSCILLATOR INJECTION PROVIDED BY STANDBY REDUNDANT LOCAL OSCILLATORS
* SYNCHRONOUS TUNED IF AMPLIFIERS PROVIDE AMPLIFICATION, FILTERING AND 40db LIMITING PRIOR TO SIGNAL DEMODULATION.
* FM DISCRIMINATOR AND INTEGRATOR GIVES COMBINED 1 and 2 kHz OUTPUT.
* OUTPUT LEVEL IS 0.8 VOLTS/RADIAN FOR AN INPUT DEVIATION OF 3.0 RADIANS.
* EMPLOYS MODULAR CONSTRUCTION ON A "MILLED" MAGNESIUM BASE PLATE.
* SIZE - 8 x 4 x 1.75 INCHES
  WEIGHT - 1.84 POUNDS
* POWER - 665 MILLIWATS (NOMINAL) AT + 12 vdc
  30 MILLIWATTS (NOMINAL) AT - 6 vdc

COMMAND RECEIVER
SIMPLIFIED BLOCK DIAGRAM



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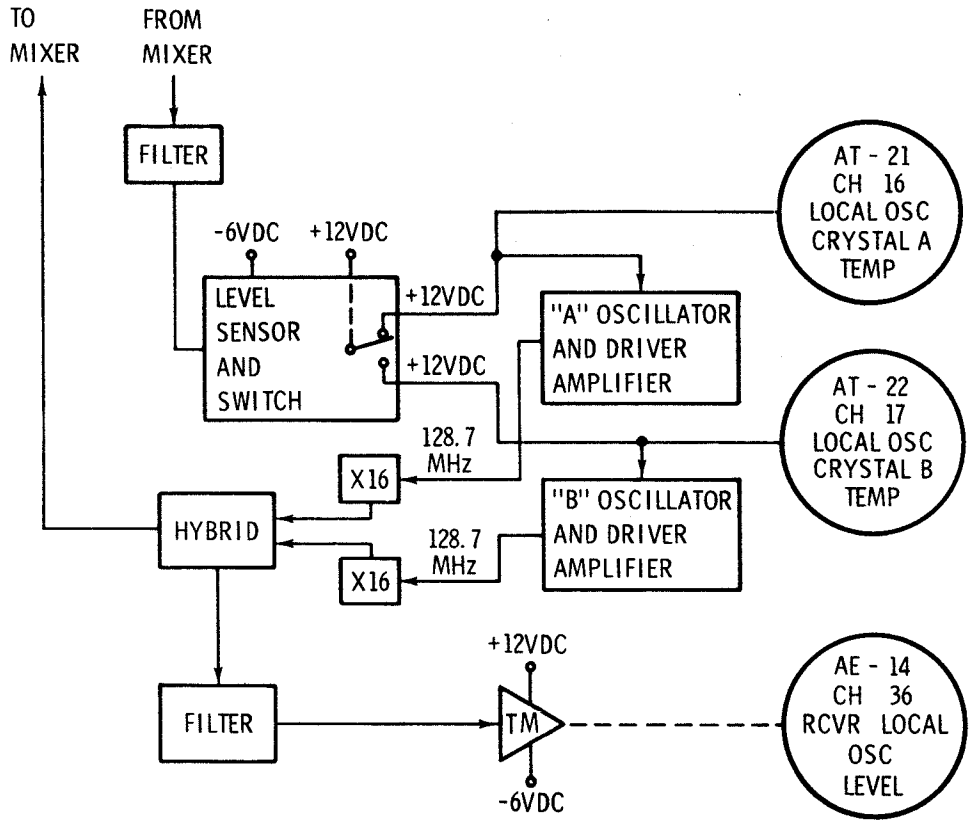
COMMAND RECEIVER
LOCAL OSCILLATOR BLOCK DIAGRAM



FEB 69 2601 7.21

COMMAND RECEIVER TELEMETRY SUMMARY

CHANNEL 36	AE-14	RCVR LOCAL OSC LEVEL * DETECTOR CIRCUIT SAMPLES OSCILLATOR SIGNAL. DETECTED SIGNAL IS THEN AMPLIFIED TO PROPER TM LEVEL
CHANNEL 16	AT-21	LOCAL OSC CRYSTAL A TEMP * USES THERMISTOR/RESISTOR NETWORK POWERED BY 12 VDC. * THERMISTOR IS CEMENTED (EPOXY) TO CRYSTAL CAN.
CHANNEL 17	AT-22	LOCAL OSC CRYSTAL B TEMP * USES THERMISTOR/RESISTOR NETWORK POWERED BY 12 VDC. * THERMISTOR IS CEMENTED (EPOXY) TO CRYSTAL CAN.
CHANNEL 9	AB-01	CMD DEMOD 1KHz PRESENT * SIGNAL IS OBTAINED FROM RECEIVER'S AUDIO OUTPUT. * USES 1KHz BANDPASS AMPLIFIER AND DIODE DETECTOR.
CHANNEL 21	AE - 13	RCVR PRE-LIMITING LEVEL * DIODES IN FINAL STAGE OF IF PROVIDE HARD LIMITING. * TM SIGNAL PROVIDED BY THE LIMITING DIODE CURRENT.

FEB 69 2601 7.22

COMMAND RECEIVER SPECIFICATIONS

*	INPUT FREQUENCY	2119 MHz ± 0.001%
*	INPUT SIGNAL LEVEL	-101dbm to -61dbm
*	NOISE FIGURE	10db MAXIMUM
*	LOCAL OSC FREQUENCY	2059 MHz ± 0.0025%/YR
*	INTERMEDIATE FREQUENCY	60 MHz
*	IF 3db BANDWIDTH	250 to 350 KHz WITH AN INPUT SIGNAL LEVEL OF -100dbm
*	IF REJECTION	60db MINIMUM AT 3.4 MHz

* AUDIO OUTPUT SIGNAL
  - (a) LEVEL - 0.8 VOLT/RADIAN (UP TO ± 3.0 RADIANS)
  - (b) FREQ - 100 Hz TO 5 KHz

* POWER

  \+ 12 VDC AT 55 MILLIAMPERES (NOMINAL) - SUPPLIED THROUGH A CIRCUIT BREAKER RATED AT 150 MILLIAMPERES (NOMINAL). CIRCUIT IS AUTOMATICALLY GIVEN A RESET COMMAND EVERY 12 HOURS DURING NORMAL SYSTEM OPERATION

  \- 6VDC AT 55 MILLIAMPERES (NOMINAL) - SYSTEM PROTECTION PROVIDED BY SERIES RESISTOR.

* CONNECTORS - RF - COAXIAL OSM 210-2
  - OTHER - HUGHES WST0014M20BNH00

FEB 69 2601 7.23

COMMAND DECODER PHYSICAL DESCRIPTION

*SIZE - 2.8 x 3.94 x 6.25 INCHES

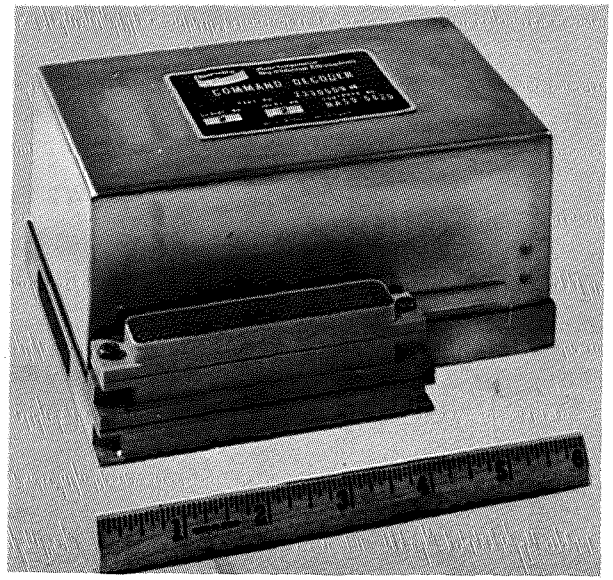
* POWER - 1330 MILLIWATTS (NOMINAL AT ROOM AMBIENT)

* WEIGHT - 2.70 LB

* PARTS COUNT - 352 FLATPACKS
  26 TRANSISTORS
  83 RESISTORS
  28 CAPACITORS
  13 DIODES

* PARTS MOUNTED ON 10 PRINTED CIRCUIT BOARDS WITH FROM 2 to 12 LAYERS

* CONNECTOR - HUGHES - 244 PIN



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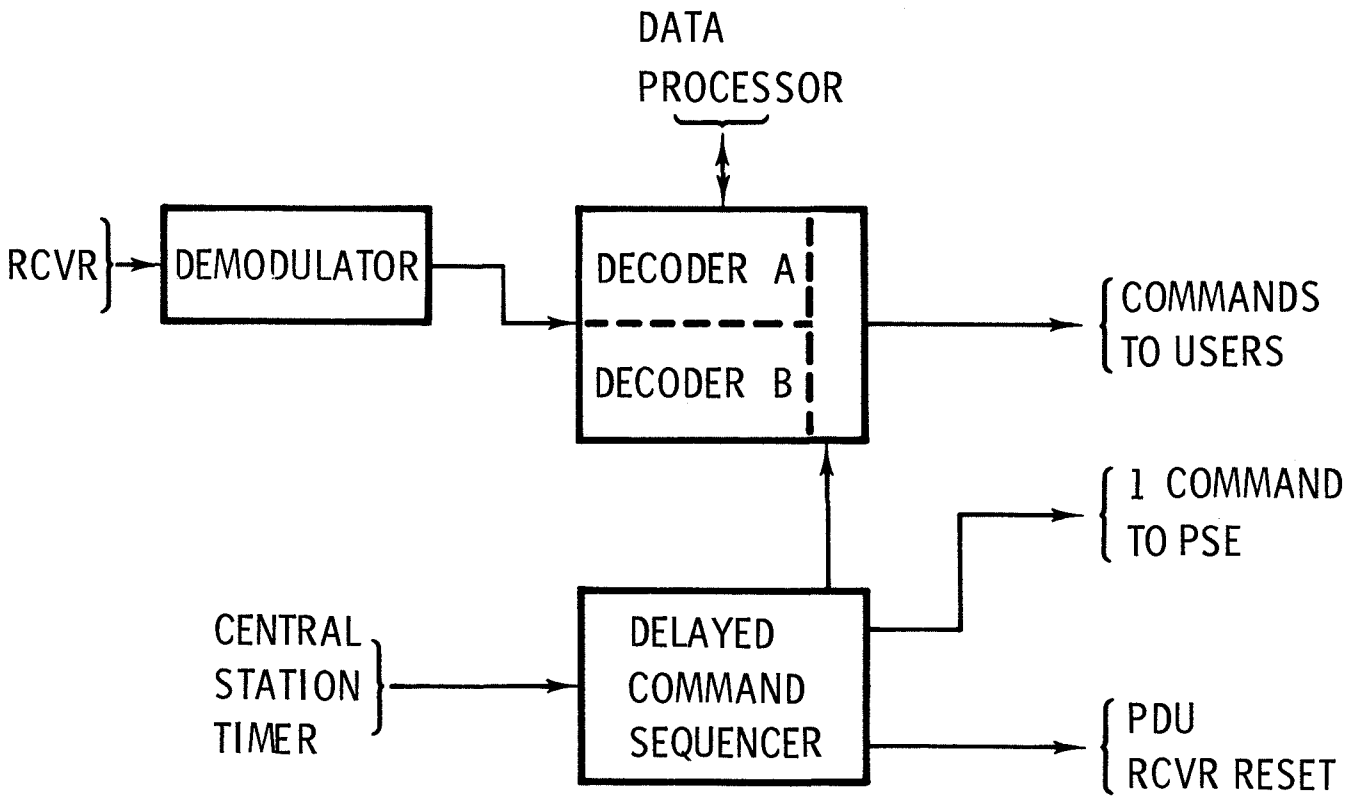
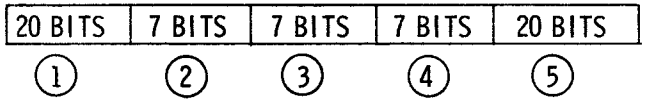
COMMAND DECODER SIMPLIFIED BLOCK DIAGRAM



FEB 69 2601 7.25

COMMAND DECODER

* CONTAINS A DEMODULATOR
  - TO GENERATE AN NRZ-C BIT STREAM FROM THE PHASE MODULATED COMPOSITE 1 & 2 KHz AUDIO INPUT
  - WHICH DETECTS " THRESHOLD" TO START DECODER "SEARCH MODE".
  - TO GENERATE 1, 2 AND 4 KHz TIMING CLOCKS WHICH ARE SYNCHRONIZED WITH THE 1 KHz SYNC SUBCARRIER RECEIVED FROM THE MSFN.
* ACCEPTS COMMAND SIGNALS FROM THE MSFN NETWORK AND PROVIDES UP TO 100 UNIQUE COMMANDS TO USERS.
* A COMMAND FROM THE MSFN CONSISTS OF A 2 KHz SUBCARRIER PHASE MODULATED WITH A 1 KHz SUBCARRIER TO PRODUCE 61 SERIAL BITS WITH THE FOLLOWING FORMAT.



1. - PREAMBLE - ALL ONE'S OR ALL ZERO'S
2. - ADDRESS INDIVIDUAL ALSEP (A or B DECODER)
3. - COMMAND COMPLEMENT
4. - COMMAND
5. - TIMING (EXECUTION) - ALL ONE'S OR ALL ZERO'S

FEB 69 2601 7.26

COMMAND DECODER ADDRESSING

* THE SEVEN ADDRESS BITS ARE USED TO UNIQUELY COMMAND PSEP OR ONE OF THREE ALSEP's ON THE LUNAR SURFACE.
* EACH COMMAND DECODER HAS AN "A" SECTION AND A REDUNDANT "B" SECTION. EITHER MAY BE SELECTED TO PROCESS A COMMAND BY TRANSMITTING THE PROPER ADDRESS CODE.

	ADDRESS NO. (OCTAL)	CODE PATTERN	MSC CONSOLE CODE
ALSEP 1	130	1011000	1A
	30	0011000	1B
PSEP	116	1001110	2A
	16	0001110	2B
ALSEP 3	151	1101001	3A
	51	0101001	3B
ALSEP 4	25	0010101	4A
	65	0110101	4B

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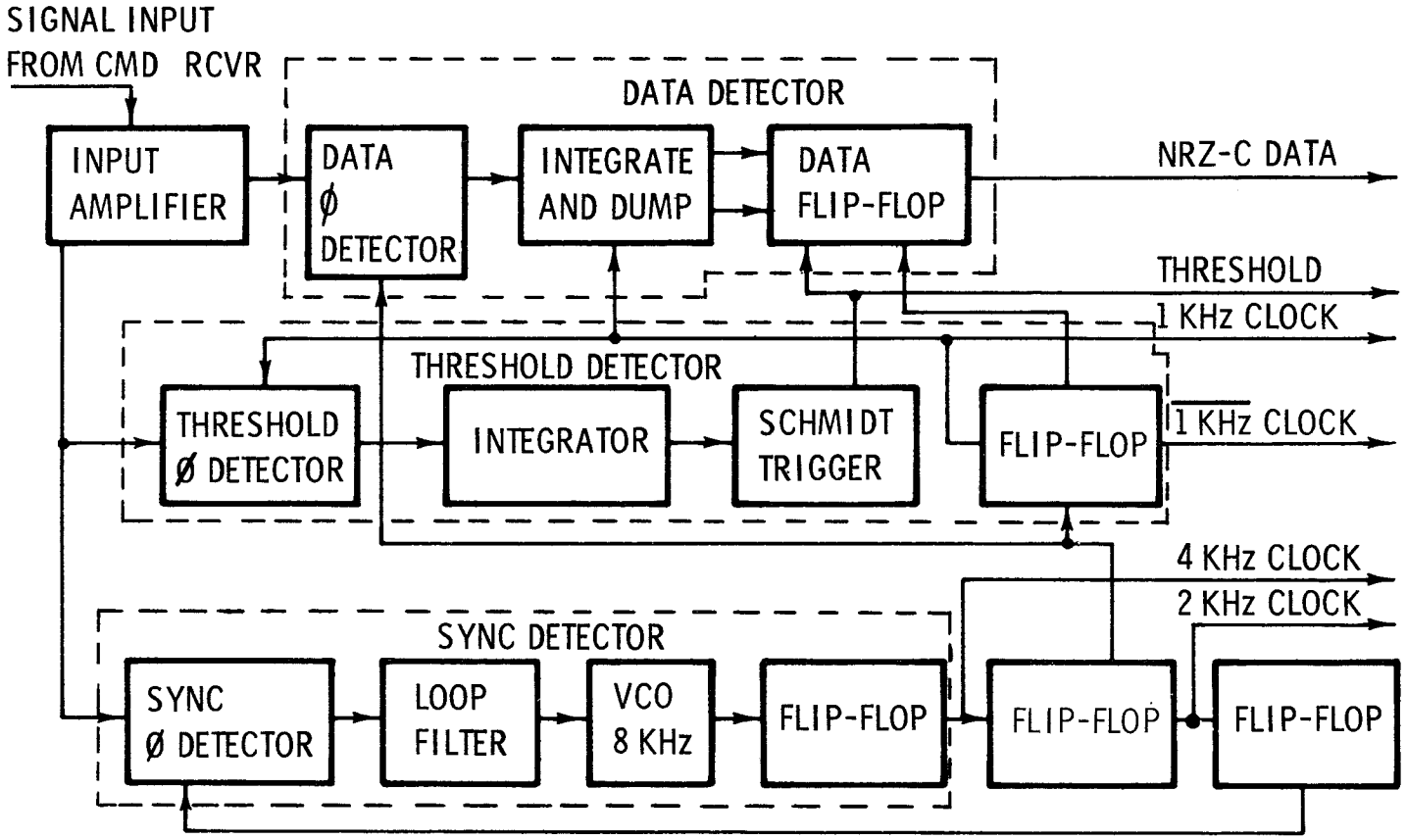
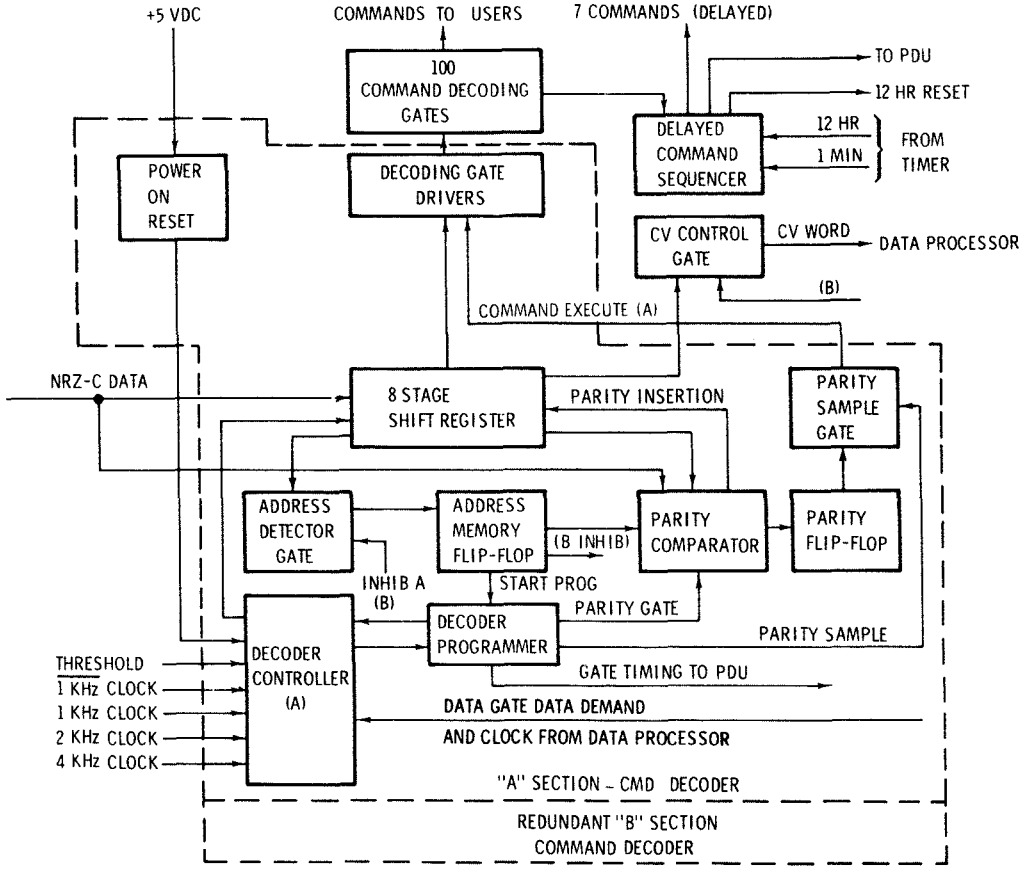
COMMAND DEMODULATOR



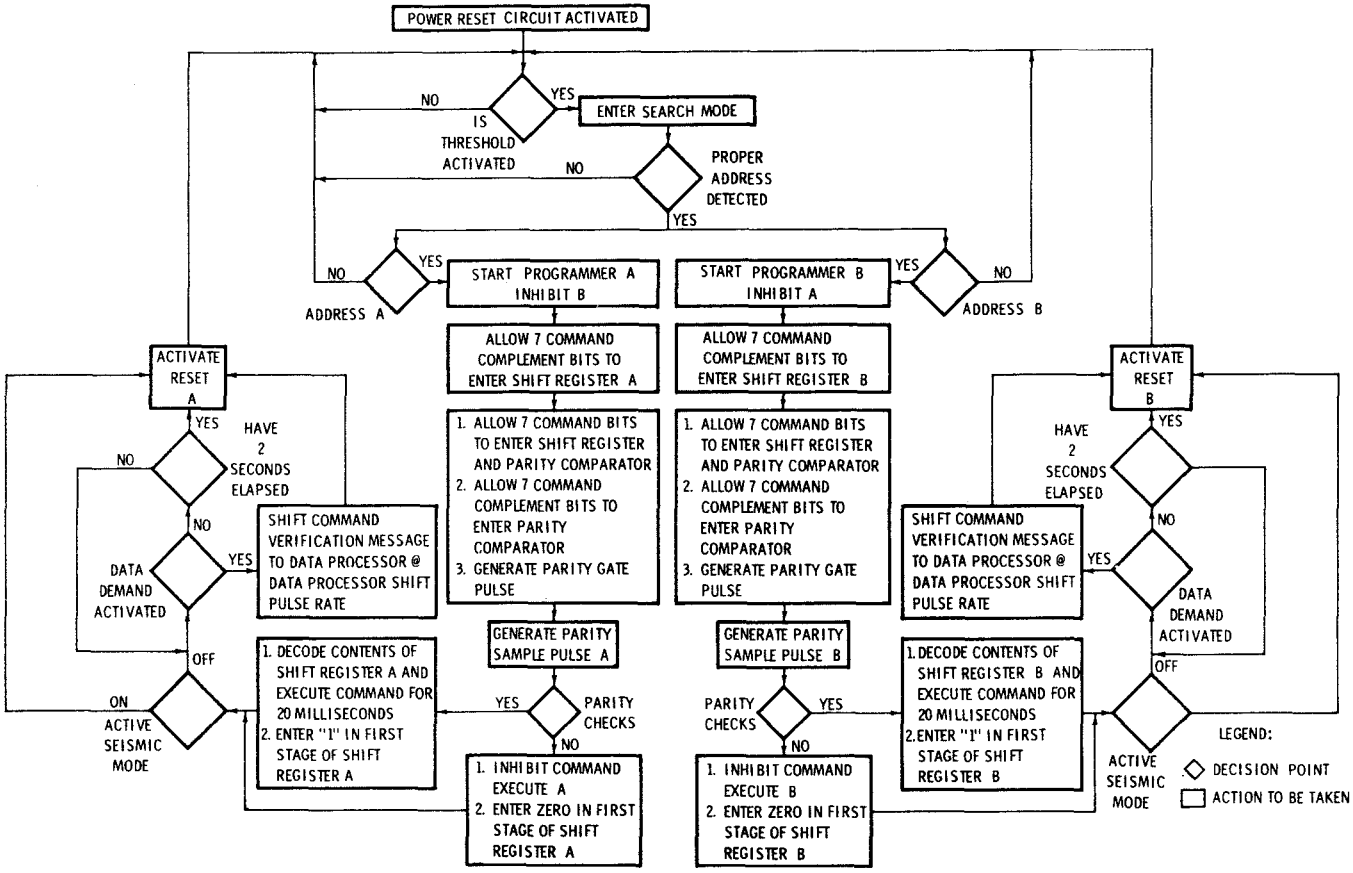
FEB 69 2601 7.28

COMMAND DECODER SECTION BLOCK DIAGRAM-DIGITAL



FEB 69 2601 7.29

FUNCTIONAL FLOW CHART COMMAND DECODER

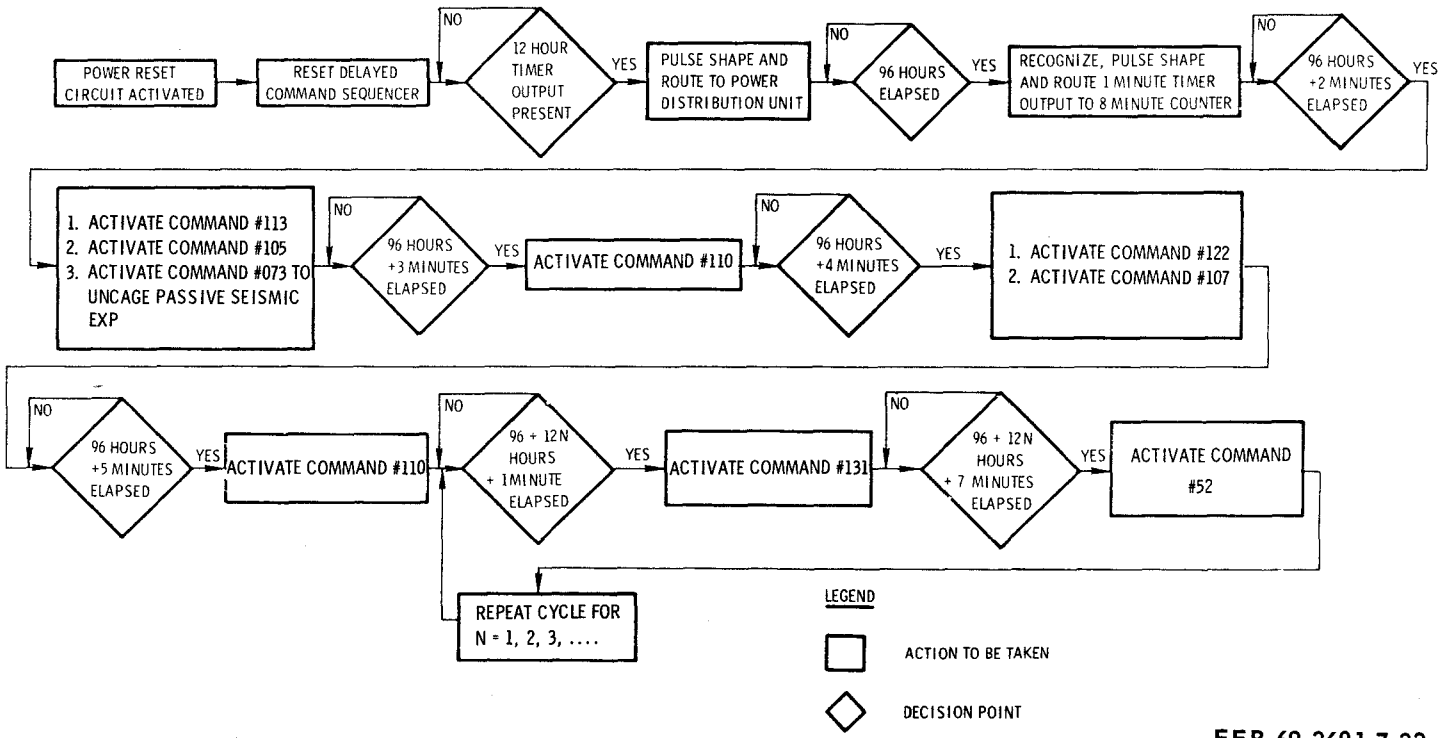


FEB 69 2601 7.30

COMMAND DECODER DELAYED COMMAND SEQUENCER

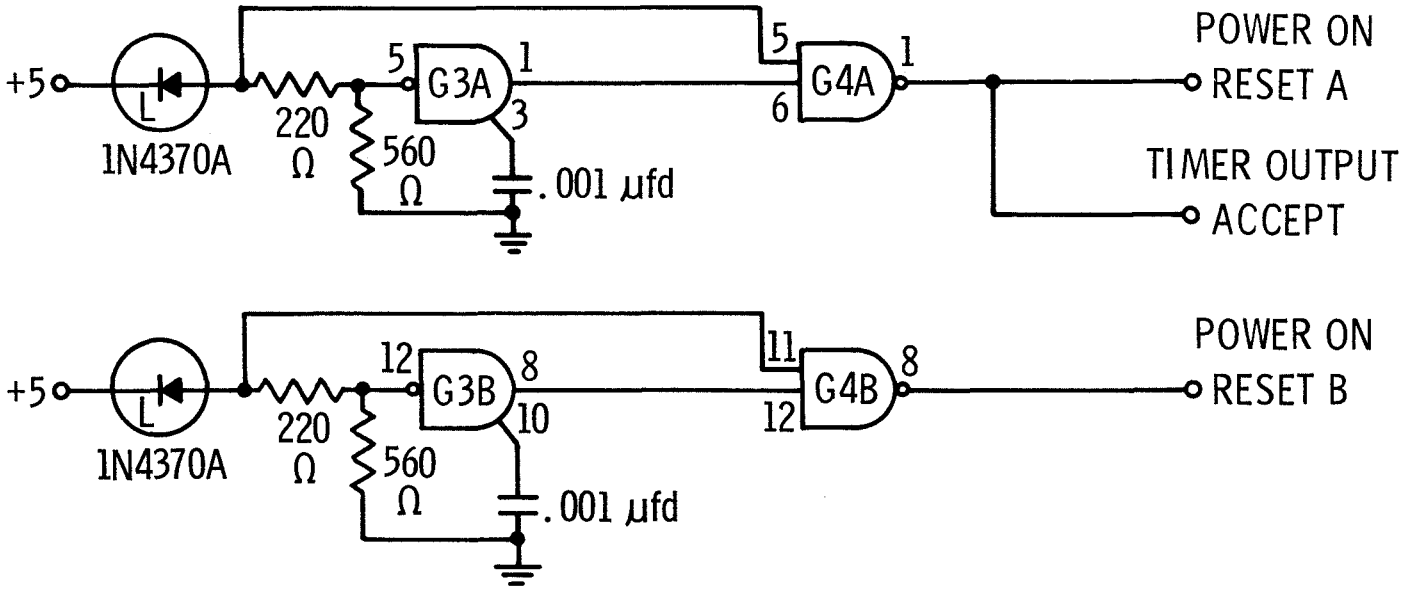
* PROVIDES A BACKUP FEATURE FOR LOCAL GENERATION OF COMMANDS IN CASE THE COMMAND LINK CANNOT BE ESTABLISHED.
* GENERATES ONE-TIME COMMAND TO UNCAGE THE PSE AFTER A DELAY OF APPROXIMATELY 96 HOURS FROM THE TIME OF SOLAR PANEL DEPLOYMENT.
* COMMAND IS IDENTICAL TO THAT GENERATED IN RESPONSE TO SIGNALS FROM THE MSFN AND ARE OR'ED IN THE COMMAND LINE DRIVER.

DELAYED COMMAND SEQUENCER FUNCTIONAL FLOW CHART



FEB 69 2601 7.32

COMMAND DECODER POWER RESET



FEATURES

DETECTS INITIAL POWER TURN-ON OR MOMENTARY POWER INTERRUPTION TO -

1. SET COMMAND DECODER IN SEARCH MODE
2. SET COMMAND DECODER IN "TIMER ACCEPT" MODE
3. START DELAYED COMMAND SEQUENCER

FEB 69 2601 7.33

COMMAND DECODER-OTHER LOCAL COMMANDS

THE FOLLOWING REPETITIVE COMMANDS ARE GENERATED WITHIN THE COMMAND DECODER.

1 - PSE CALIBRATE - COMMAND #065

* OCCURS EVERY TIME A 12-HOUR TIMER PULSE IS ISSUED.

2 - RECEIVER CIRCUIT BREAKER RESET

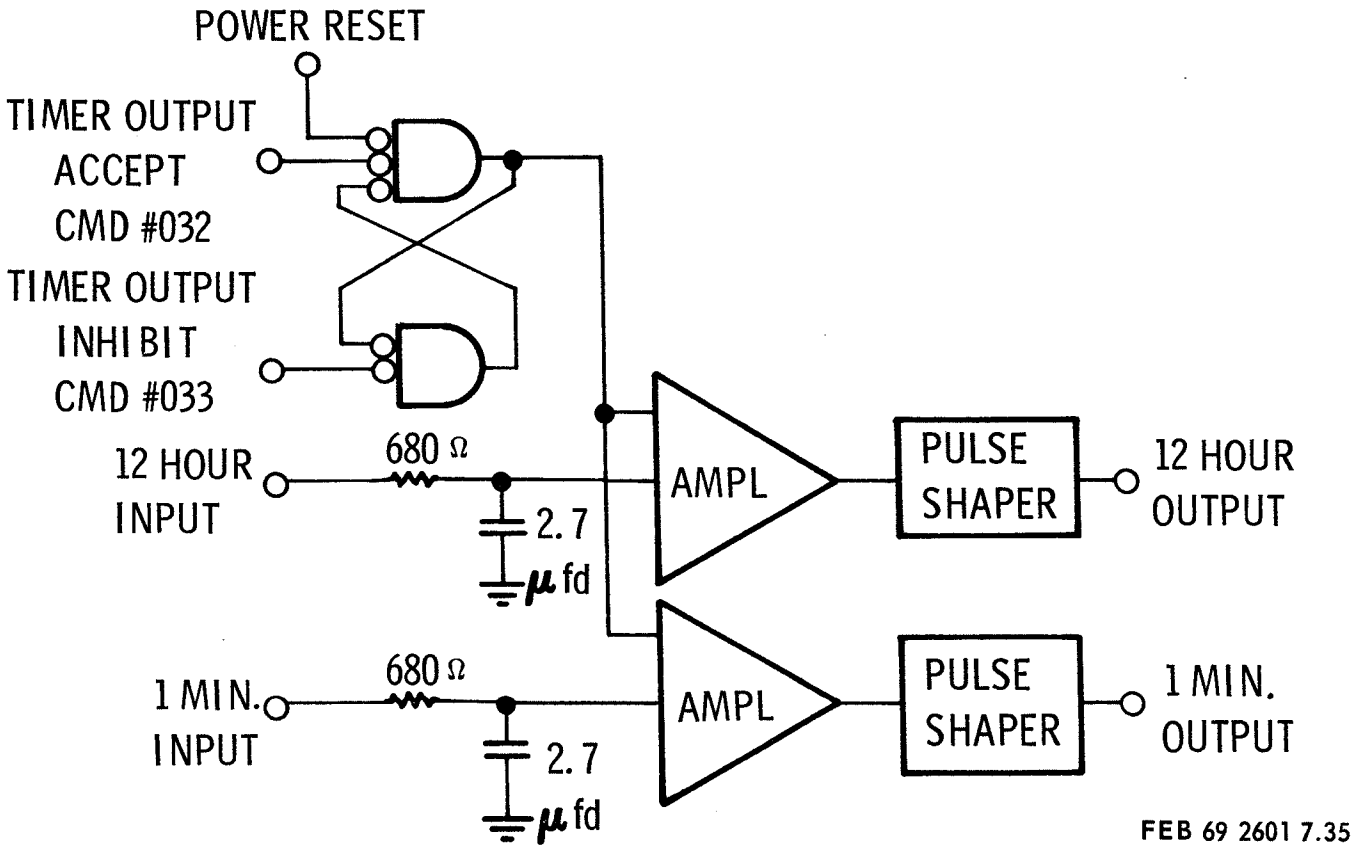
* OCCURS EVERY TIME A 12-HOUR TIMER PULSE IS ISSUED.

* ALL ABOVE COMMANDS MAY BE INHIBITED BY TRANSMITTING COMMAND #033.

➤ COMMAND #033 IS CONSIDERED CRITICAL! SHOULD THE COMMAND LINK BE LOST FOLLOWING TRANSMISSION OF CMD #033, THEN ALL LOCALLY GENERATED COMMANDS WOULD BE LOST.

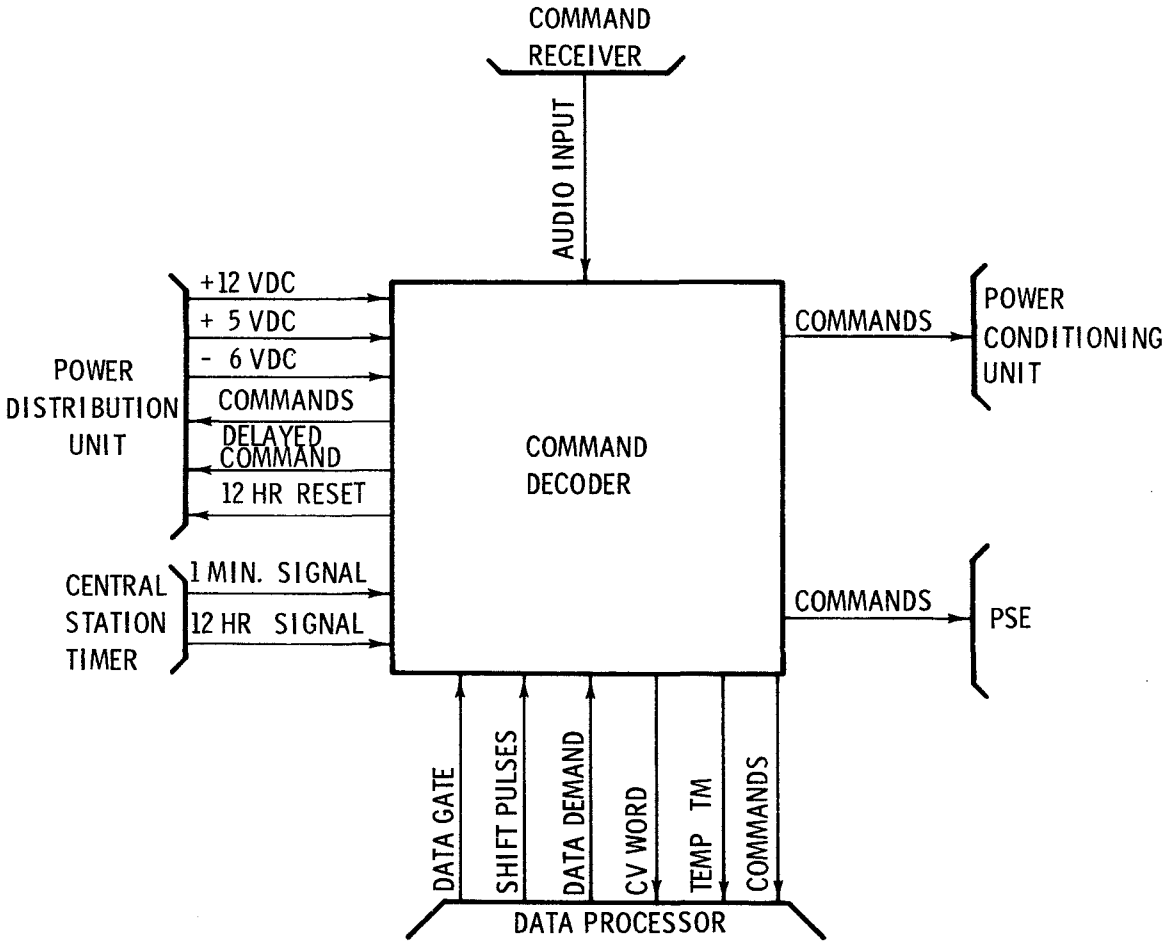
FEB 69 2601 7.34

TIMER/COMMAND DECODER INTERFACE



FEB 69 2601 7.35

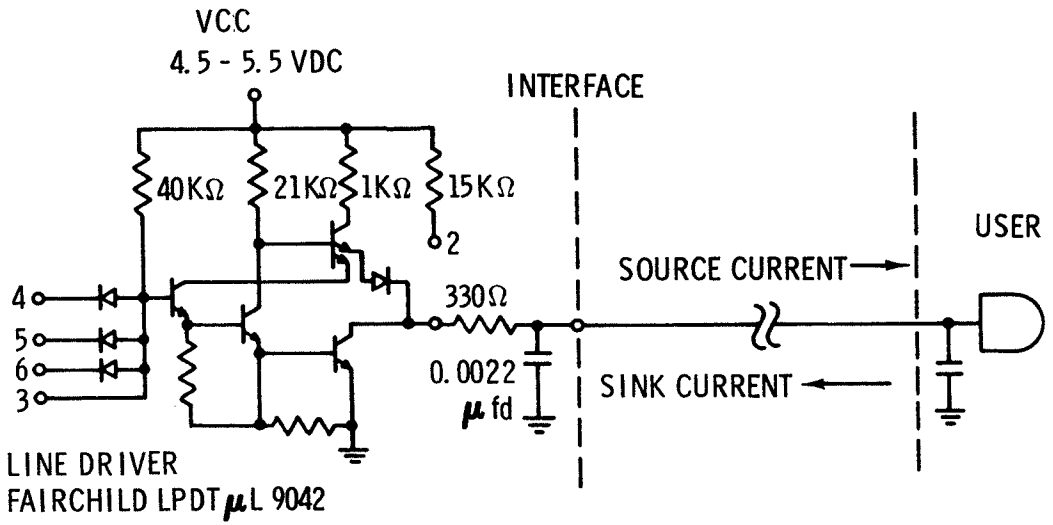
COMMAND DECODER INTERFACE

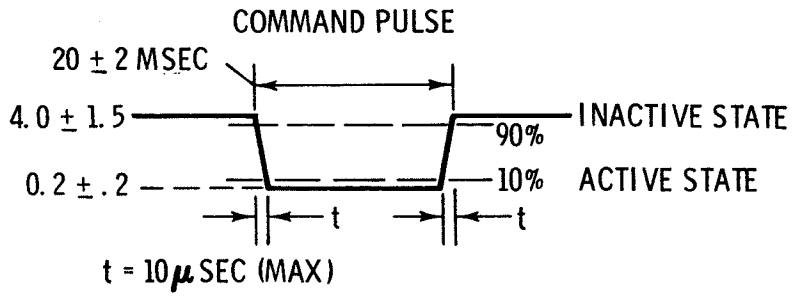


FEB 69 2601 7.36

COMMAND DECODER INTERFACE CIRCUIT

(ONE EACH FOR 100 COMMANDS)





DRIVER SPECIFICATION

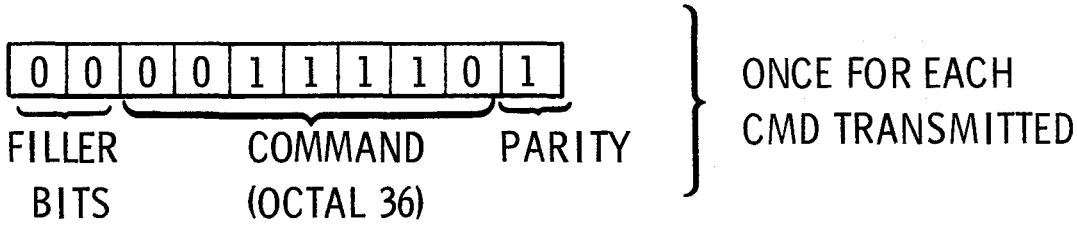
SOURCE I ≤ 45μ AMP
(INACTIVE STATE)

SINK I ≤ 750μ AMP
(ACTIVE STATE)

FEB 69 2601 7.37

COMMAND DECODER TELEMETRY SUMMARY

* COMMAND VERIFICATION (CV) WORD
  - LOCATED IN WORD 46 OF TELEMETRY FORMAT FOR PSEP
  - CONSISTS OF 2 ZERO'S, THE RECEIVED COMMAND AND A PARITY BIT.
  - EXAMPLE OF CV WORD RECEIVED AT THE MSFN.



  - PARITY " ONE" VERIFIES BIT BY BIT CHECK OF COMMAND WITH COMPLEMENT.
  - THE SEVEN COMMAND BITS IDENTIFY THE BINARY CODE DETECTED BY THE COMMAND DECODER.

COMMAND DECODER TELEMETRY SUMMARY

CHANNEL 48 AT-31 COMMAND DECODER BASE TEMP

*SIGNAL OBTAINED FROM THERMISTOR LOCATED NEAR CENTER OF BASE PLATE

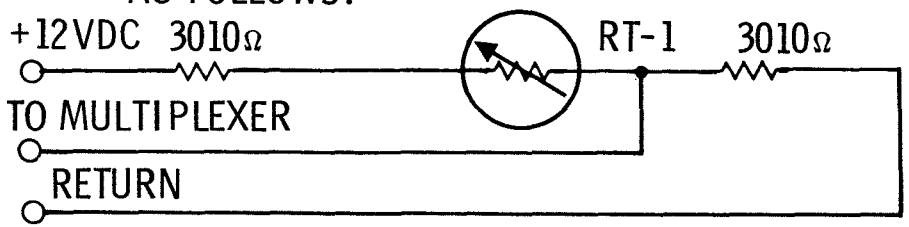
CHANNEL 49 AT-32 COMMAND DECODER INTERNAL TEMP

*THERMISTOR LOCATED ON "PULSE SHAPER" PRINTED CIRCUIT BOARD

CHANNEL 61 AT-33 COMMAND DEMODULATOR, VCO TEMP

*THERMISTOR LOCATED ON DEMODULATOR PRINTED CIRCUIT BOARD

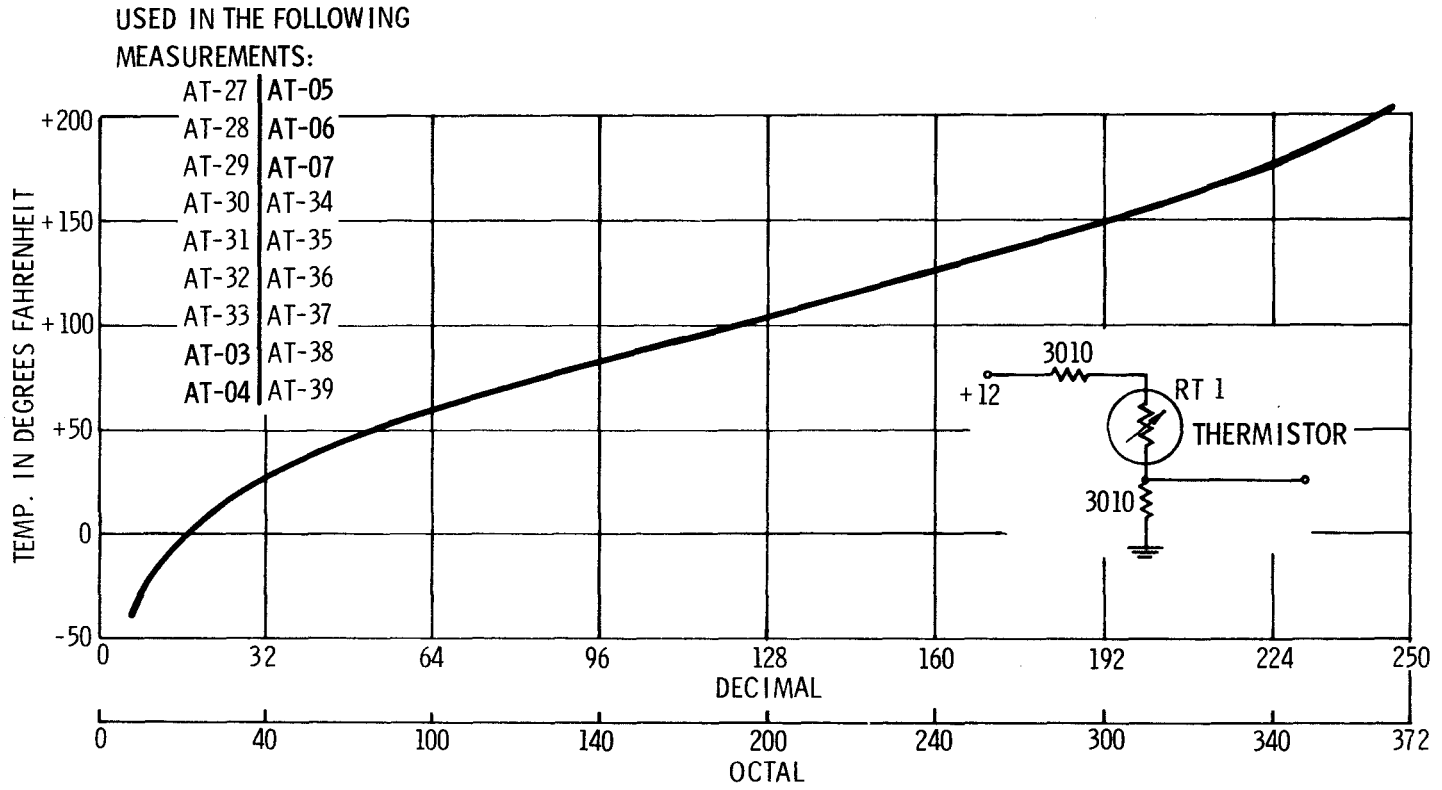
CIRCUITS - TEMPERATURE SENSING CIRCUITS ARE ARRANGED AS FOLLOWS:



RT-1 "FENWAL" ISO-CURVE 15K ohm THERMISTOR.

FEB 69 2601 7.39

TELEMETRY READOUT VS. TEMPERATURE



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PSEP TELEMETRY LINK

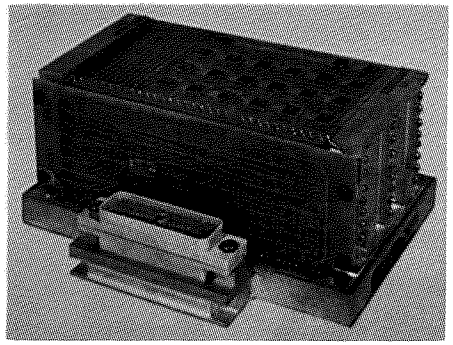
* DIGITAL DATA PROCESSOR (DDP)
* MULTIPLEXER/CONVERTER
* TRANSMITTERS (TWO)
* DIPLEXER/SWITCH
* ANTENNA

FEB 69 26017.41

DIGITAL DATA PROCESSOR

THE DIGITAL DATA PROCESSOR -

* IS THE FOCAL POINT FOR THE COLLECTION, FORMATTING AND CONTROL OF ALL TELEMETERED DATA.
* CONTAINS COMMAND SELECTABLE "X" AND "Y" SECTIONS. EXCEPT FOR THE FRAME COUNTER AND INTERFACE CIRCUITS, THE DDP IS FULLY REDUNDANT.
* HAS 3 MODES OF OPERATION DEFINED AS "NORMAL" (1060BPS), "SLOW"(530BPS)AND "ACTIVE SEISMIC". PSEP PROVIDES NO DATA IN "ACTIVE SEISMIC" MODE.
* USES A CRYSTAL OSCILLATOR TO DERIVE ALL TIMING AND CONTROL SIGNALS.
* COLLECTS DATA INTO A 64 WORD FRAME REPEATING EACH 604 MILLISECONDS. EACH WORD CONSISTS OF 10 BITS OR ABOUT 9.43 MILLISECONDS (NORMAL MODE).
* PROCESSES COLLECTED DATA INTO THE REQUIRED TELEMETRY FORMAT IN SERIAL FORM. EACH DATA SOURCE IS SAMPLED AT LEAST ONCE PER FRAME.



FEB 2601 7.42

DIGITAL DATA PROCESSOR

PHYSICAL DESCRIPTION -

SIZE - 2.8 X 3.94 X 6.25 INCHES

WEIGHT - 3.03 LB

POWER - 450 MILLIWATTS AT 5 VDC
50 MILLIWATTS AT 12 VDC
(NOMINAL AT ROOM AMBIENT TEMPERATURE)

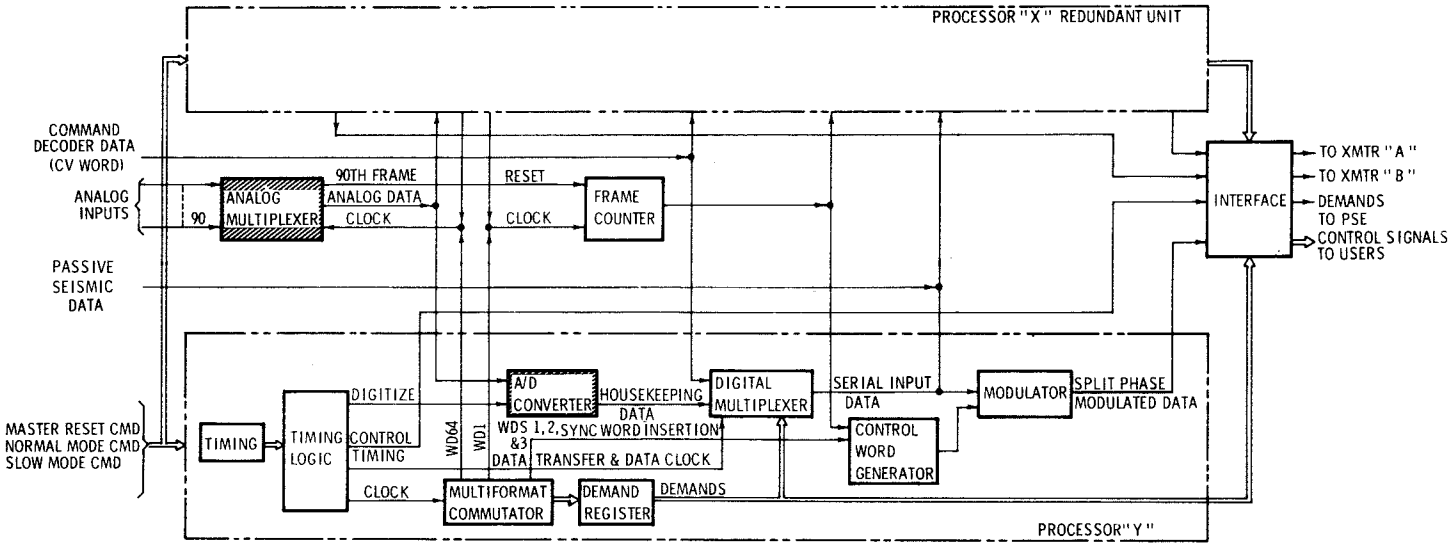
PARTS COUNT - 199 FLATPACKS
2 TRANSISTORS
41 RESISTORS
19 CAPACITORS
3 DIODES

PARTS ARE MOUNTED ON 9 PRINTED CIRCUIT BOARDS WITH FROM 3 TO 12 LAYERS.

CONNECTOR - HUGHES - 244 PIN

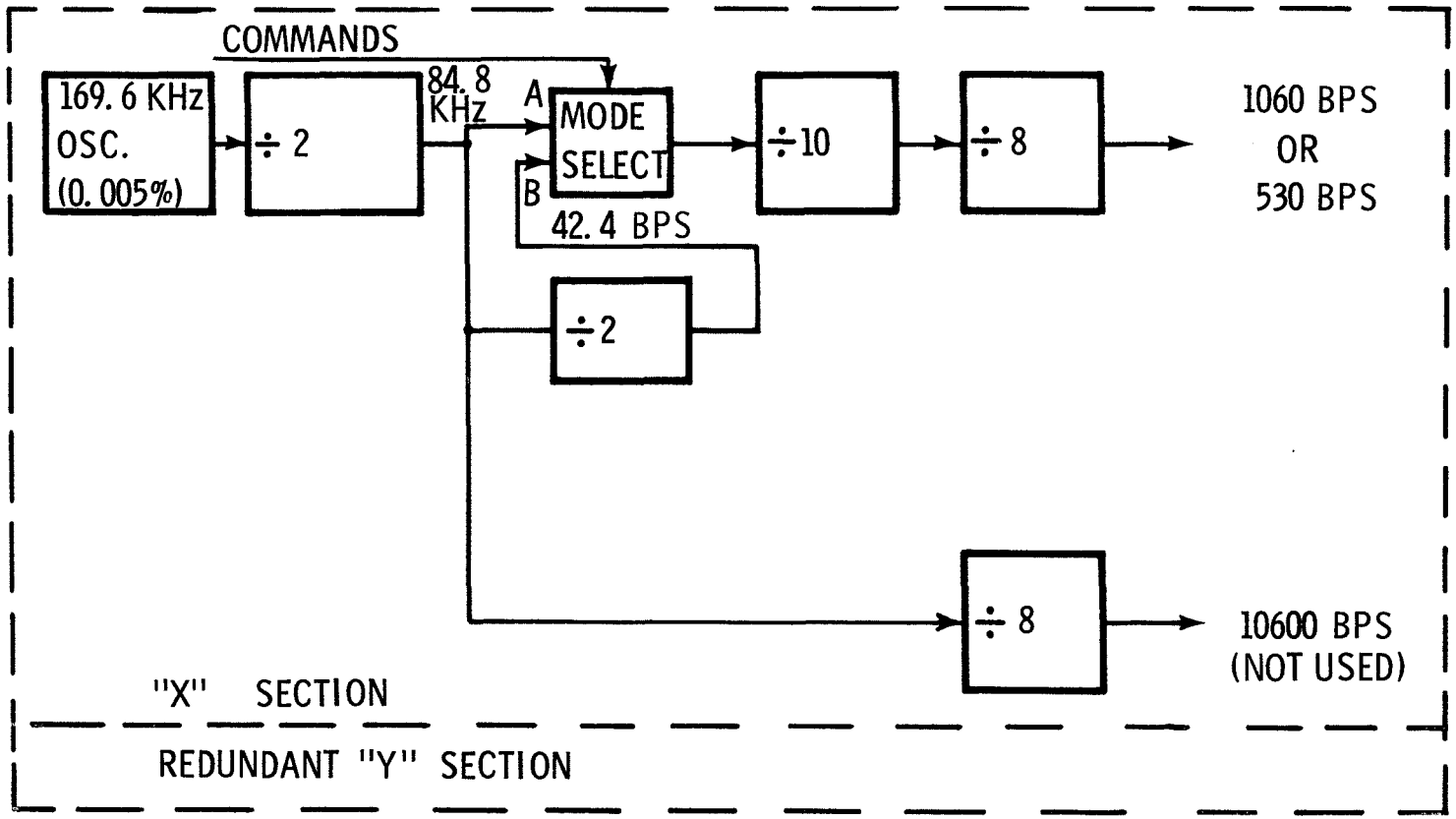
FEB 69 2601 7.43

DATA PROCESSOR
SIMPLIFIED BLOCK DIAGRAM



FEB 69 2601 7.44

GENERATION OF BASIC CLOCKS



A - NORMAL MODE

B - SLOW MODE

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DIGITAL DATA PROCESSOR

*CONTROL WORD GENERATOR - GENERATES THE 22-BIT SYNCHRONIZATION CODE
- PROVIDES MODE, FRAME AND ALSEP ID IN THE LAST 8 BITS OF THE 30-BIT SYNC WORD

*SPLIT PHASE MODULATOR - ENCODES DATA INTO INTO A "SPIT PHASE" SIGNAL
- PCM "0" IS REPRESENTED BY "01" AND CAUSES A POSITIVE PHASE TRANSITION
- PCM "1" IS REPRESENTED BY A "10" AND CAUSES NEGATIVE PHASE TRANSITION

*FRAME COUNTER - IS NOT REDUNDANT
- CONTAINS A COUNTER WHICH IS ADVANCED ONE STEP PER 64 WORD FRAME
- IS RESET BY A 90TH FRAME "END OF FRAME" SIGNAL FROM THE MULTIPLEXER/CONVERTER

*MULTIFORMAT COMMUTATOR - USES 2 DIVIDE BY 8 COUNTERS WITH GATING FOR ANY ONE OF 64 CONSECUTIVE PERIODS (WORDS)
- PRODUCES SIGNALS OF ONE WORD LENGTH AND MULTIPLES OF ONE WORD LENGTH TO SELECT AND GATE DATA INTO A MODULATOR
- CONTAINS A "PATCH PLANE" FOR FLEXIBLE WORD ASSIGNMENTS

*DEMAND REGISTER - ACTS AS A BUFFER BETWEEN THE DEMAND DECODER ASSEMBLY AND THE DEMAND LINES TO ELIMINATE GATING TRANSIENTS
- ACTS AS A MASTER SWITCH TO INHIBIT ALL DEMANDS DURING ASE MODE

*DIGITAL MULTIPLEXER - CONTAINS A 10-BIT SHIFT REGISTER TO ACCEPT 8 PARALLEL BITS FROM THE A/D CONVERTER OR 8 SERIAL BITS FROM THE COMMAND DECODER
- SHIFTS OUT 10-BIT WORDS WITH "ZEROS" IN THE TWO MOST SIGNIFICANT FIGURES. BITS ARE SHIFTED HIGH ORDER FIRST.

FEB 69 2601 7.46

PSEP DATA FORMAT MATRIX PRESENTATION

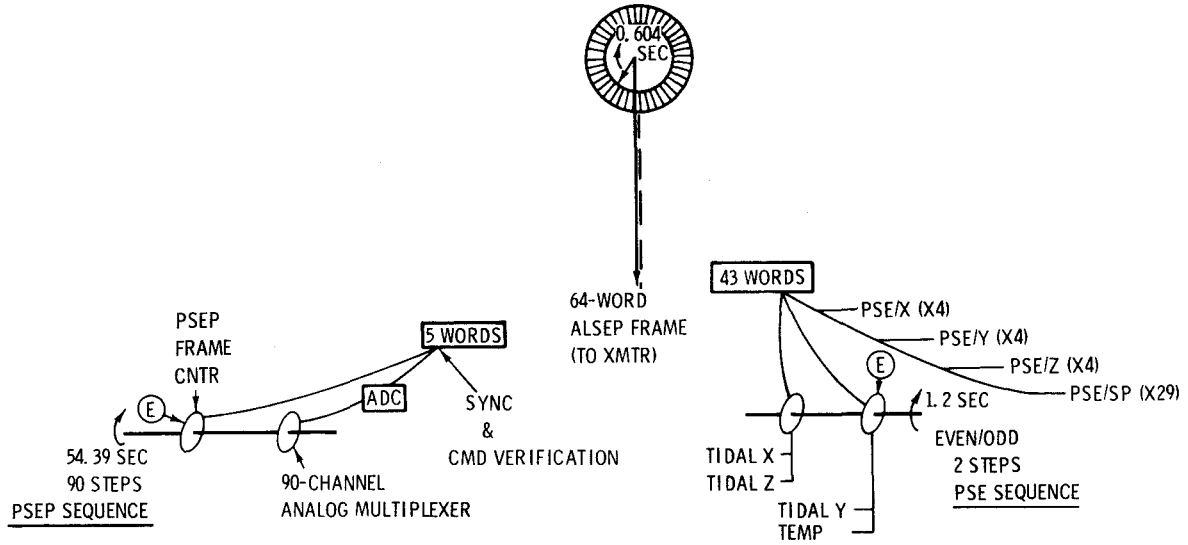
1 x	2 x	3 x	4 X	5 –	6 X	7 –	8 X
9 *	10 X	11 *	12 X	13 *	14 X	15 –	16 X
17 –	18 X	19 –	20 X	21 –	22 X	23 –	24 X
25 *	26 X	27 *	28 X	29 *	30 X	31 –	32 X
33 H	34 X	35 •	36 X	37 •	38 X	39 –	40 X
41 *	42 X	43 *	44 X	45 *	46 CV	47 –	48 X
49 –	50 X	51 –	52 X	53 –	54 X	55 –	56 –
57 *	58 X	59 *	60 X	61 *	62 X	63 –	64 X

# OF WORDS PER FRAME	LEGEND	ASSIGNMENTS
3	x	CONTROL
29	X	PASSIVE SEISMIC (SHORT PERIOD)
12	*	PASSIVE SEISMIC (LONG PERIOD SEISMIC)
2	•	PASSIVE SEISMIC (LONG PERIOD TIDAL + TEMP)
1	CV	COMMAND VERIFICATION (ALL ZERO'S IF NO COMMAND)
1	H	HOUSEKEEPING
16	–	NOT ASSIGNED (ALL ONE'S TRANSMITTED)

EACH BOX CONTAINS ONE 10 BIT WORD. TOTAL REPRESENTS ONE FRAME OR 640 BITS.

FEB 69 2601 7.47

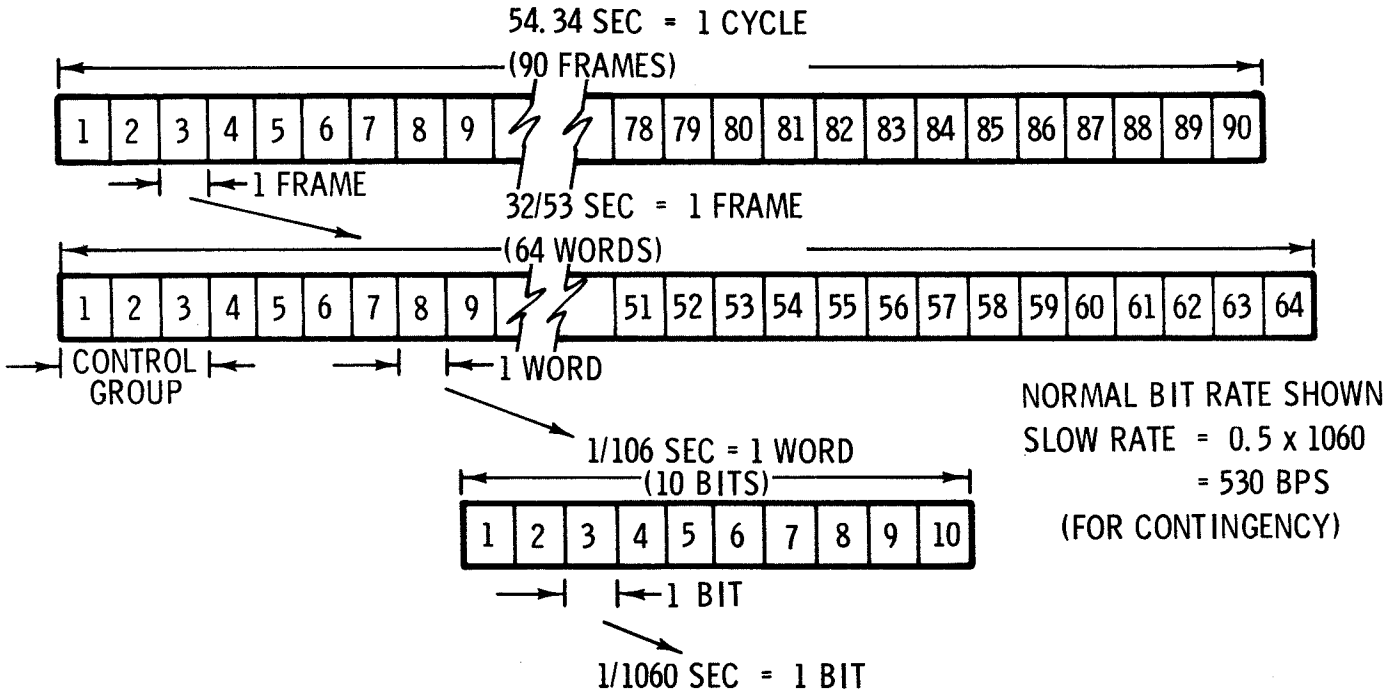
PSEP DATA FORMAT
COMMUTATOR PRESENTATION



NOTE: TIMES ARE FOR NORMAL BIT RATE

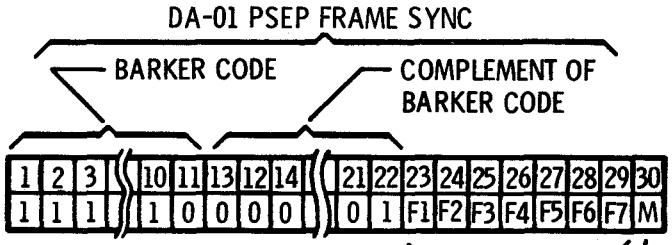
FEB 69 2601 7.48

PSEP DATA FORMAT LINEAR PRESENTATION



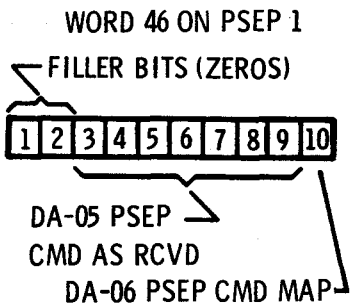
FEB 69 2601 7.49

CONTROL WORDS AND CMD VERIFICATION



MODE BIT, DEFINED AS FOLLOWS:

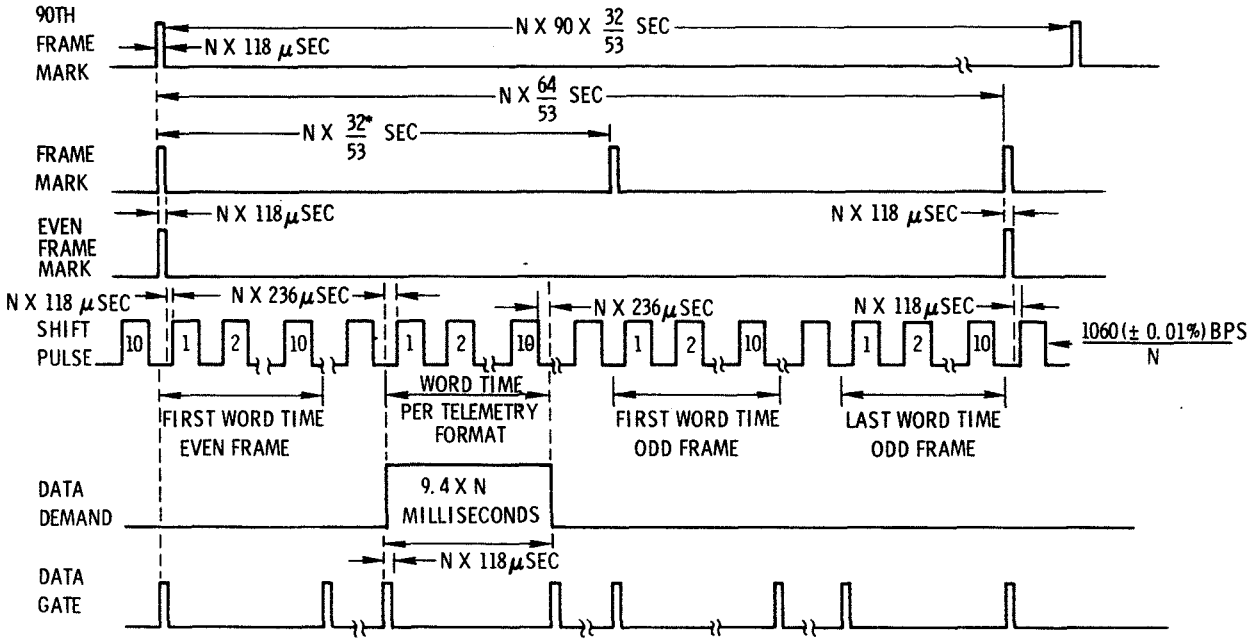
FRAME	MODE BIT	MEANING	
1	1	NORMAL BIT RATE	DA-03 PSEP BIT RT ID
2	1	LOW BIT RATE	
3	X MSB	DATA PROC ID NO.	DA-04 PSEP ID
4	X		
5	X		
6	NONE	NONE	
•	"	"	
•	"	"	
•	"	"	
89	"	"	
0	NONE	NONE	



ONE WORD SAMPLE AS EACH COMMAND IS RECEIVED AT PSEP, AT OTHER TIMES THE SAMPLE IS ALL ZEROS

FEB 69 2601 7.50

DATA PROCESSOR TIMING/CONTROL SIGNALS



N = 1 FOR NORMAL MODE OF 1060 BPS

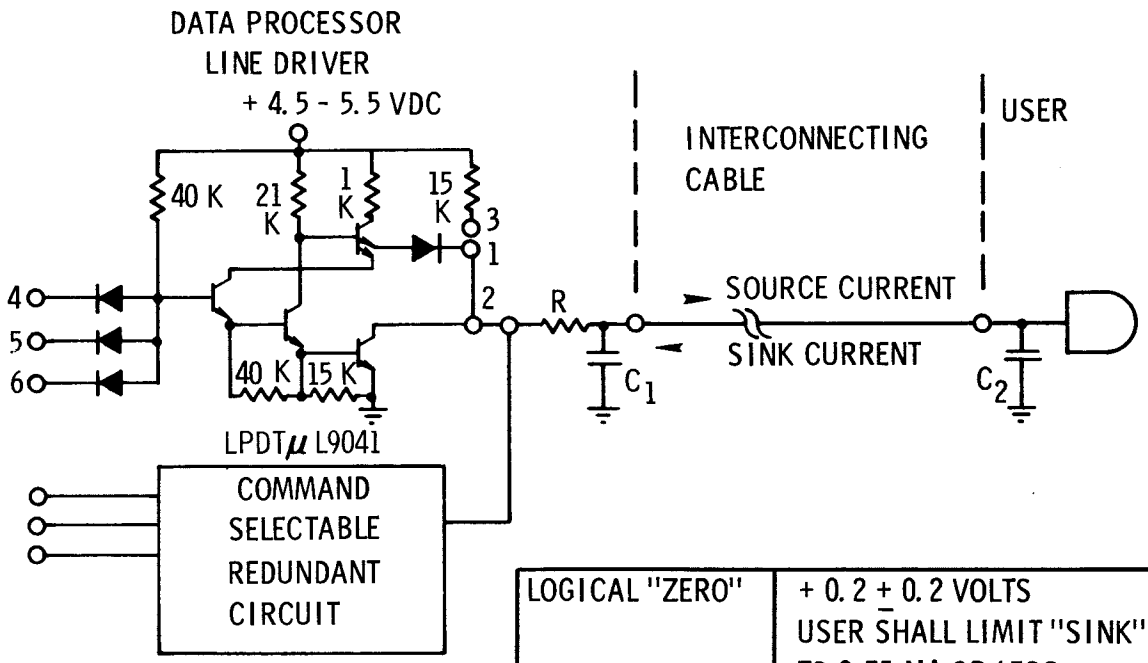
N = 2 FOR SLOW MODE OF 530 BPS

LOGIC LEVELS: "ONE", + 4.0 ± 1.5 VOLTS; "ZERO", + 0.2 ± 0.2 VOLTS

*$\frac{32}{53}$ SEC = $\frac{640 \text{ BITS PER FRAME}}{1060 \text{ BPS}}$ ALL OTHER TIMES ARE ACCURATE ONLY TO THE SIGNIFICANT FIGURE SHOWN.

FEB 69 2601 7.51

TIMING/CONTROL SIGNAL INTERFACE

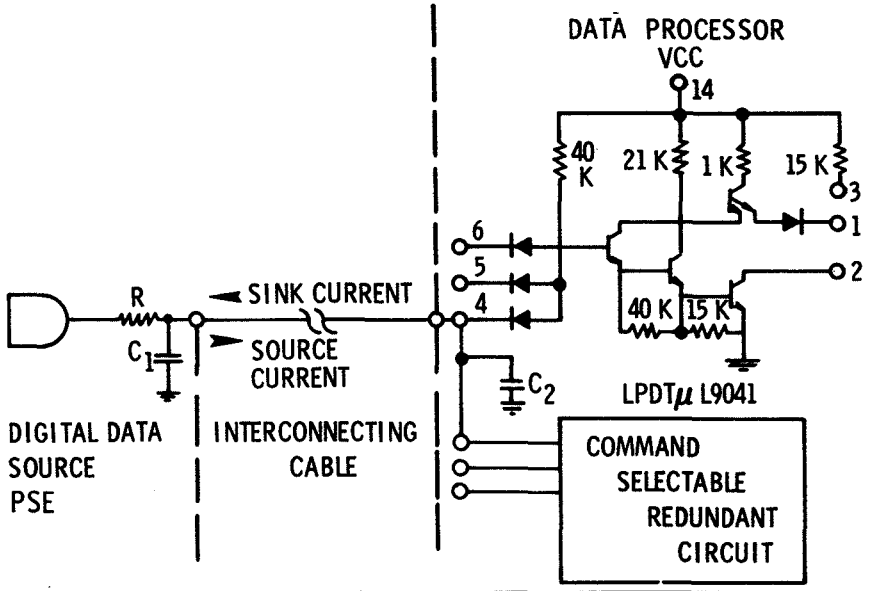


LOGICAL "ZERO"	+ 0.2 ± 0.2 VOLTS USER SHALL LIMIT "SINK" CURRENT TO 0.75 MA OR LESS
LOGICAL "ONE"	+ 4.0 ± 1.5 VOLTS USER SHALL LIMIT "SOURCE" CURRENT TO 0.045 MA OR LESS
R, C_1 & C_2	CONTROL RISE AND FALL TIME

FEB 69 2601 7.52

EXPERIMENT/DATA PROCESSOR INTERFACE

DIGITAL DATA



LOGICAL "ZERO"	+ 0.2 ± 0.2 VOLTS THE SOURCE LINE DRIVER MUST BE CAPABLE OF "SINKING" UP TO 0.215 MA
LOGICAL "ONE"	+ 4.0 ± 1.5 VOLTS THE SOURCE LINE DRIVER MUST BE CAPABLE OF "SOURCING" UP TO 0.012 MA
R, C1, & C2	CONTROL RISE AND FALL TIME

FEB 69 2601 7.53

DIGITAL DATA PROCESSOR TELEMETRY SUMMARY

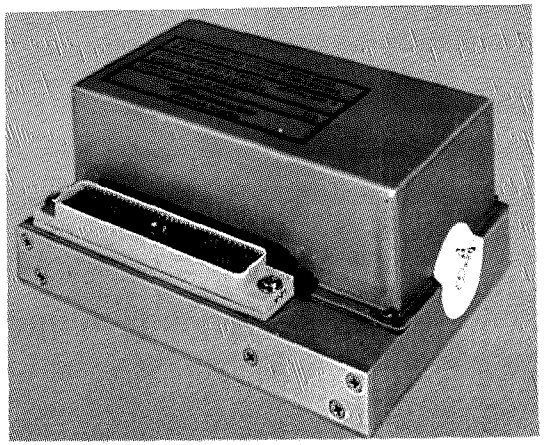
CHANNEL 2	AE-01	0.25 VDC CALIBRATION OF ADC A ZENER DIODE AND RESISTIVE DIVIDER IS USED TO PROVIDE AN ACCURATE REFERENCE VOLTAGE FOR TM CHANNEL CALIBRATION.
CHANNEL 3	AE-02	4.75 VDC CALIBRATION OF ADC THIS VOLTAGE IS OBTAINED FROM THE SAME NETWORK AS THE 0.25 VDC AND PROVIDES A SECOND CALIBRATION POINT.
CHANNEL 46	AT-29	DIGITAL DP, BASE TEMPERATURE USES A THERMISTOR LOCATED ON THE BASE PLATE.
CHANNEL 47	AT-30	DIGITAL DP, INTERNAL TEMPERATURE USES A THERMISTOR LOCATED ON ONE OF THE PRINTED CIRCUIT BOARDS.

FEB 69 2601 7.54

ANALOG MULTIPLEXER/CONVERTER

THE COMPONENT -

- CONSISTS OF A 90 CHANNEL ANALOG MULTIPLEXER, A SEQUENCER, BUFFER AMPLIFIERS AND TWO EIGHT-BIT A/D CONVERTERS WITH BUFFERED OUTPUTS.
- USES REDUNDANT GATES, DRIVERS AND A/D CONVERTERS FOR RELIABLE OPERATION.
- MONITORS UP TO 90 DATA SOURCES ON A SEQUENTIAL SAMPLE BASIS. REQUIRES ABOUT 54 SECONDS FOR ONE COMPLETE SEQUENCE OF SAMPLES.
- CONVERTS EACH INPUT INTO AN 8-BIT BINARY WORD.
- PROVIDES THE 8-BIT BINARY WORD IN PARALLEL TO THE DIGITAL MULTIPLEXER OF THE DDP.



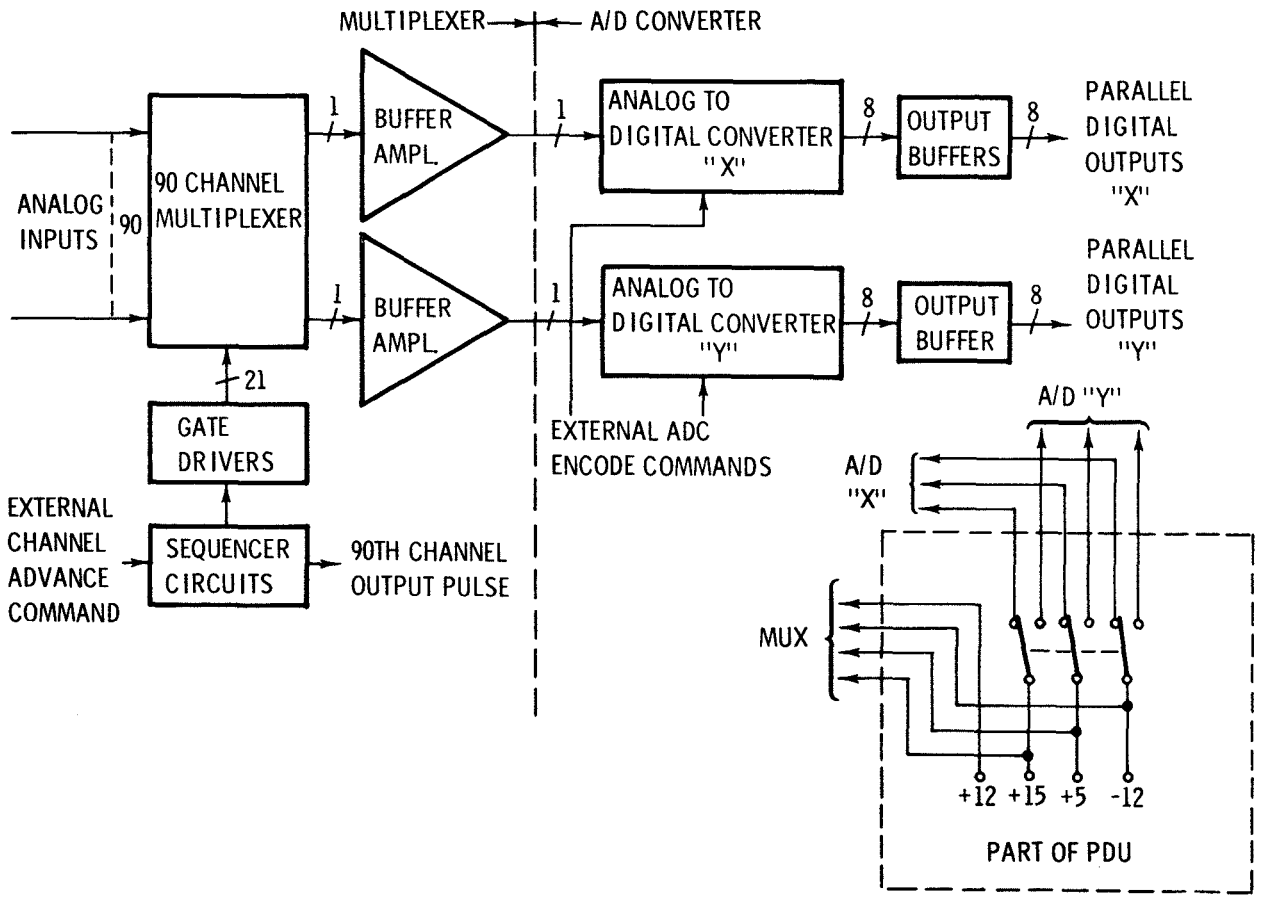
FEB 69 2601 7.55

ANALOG MULTIPLEXER/CONVERTER
PHYSICAL DESCRIPTION

SIZE	2.62 x 4.23 x 5.92 inches	
WEIGHT	2.2 pounds	
POWER	REQUIRES A TOTAL OF 1435 MILLIWATTS (NOMINAL AT ROOM AMBIENT) AT THE FOLLOWING VOLTAGE LEVELS-	
	65 milliwatts at + 15 vdc	
	150 milliwatts at + 12 vdc	
	1100 milliwatts at + 5 vdc	
	120 milliwatts at - 12 vdc	
PARTS COUNT	INTEGRATED CIRCUITS	76
	FIELD EFFECT TRANSISTORS	156
	TRANSISTORS	185
	DIODES	307
	ZENER DIODES	9
	CAPACITORS	158
	RESISTORS	102
	CRYSTALS	2
PACKAGING	ALL PARTS ARE MOUNTED ON 15 TWO LAYER PCBs	
CONNECTOR	HUGHES - 244 PIN	

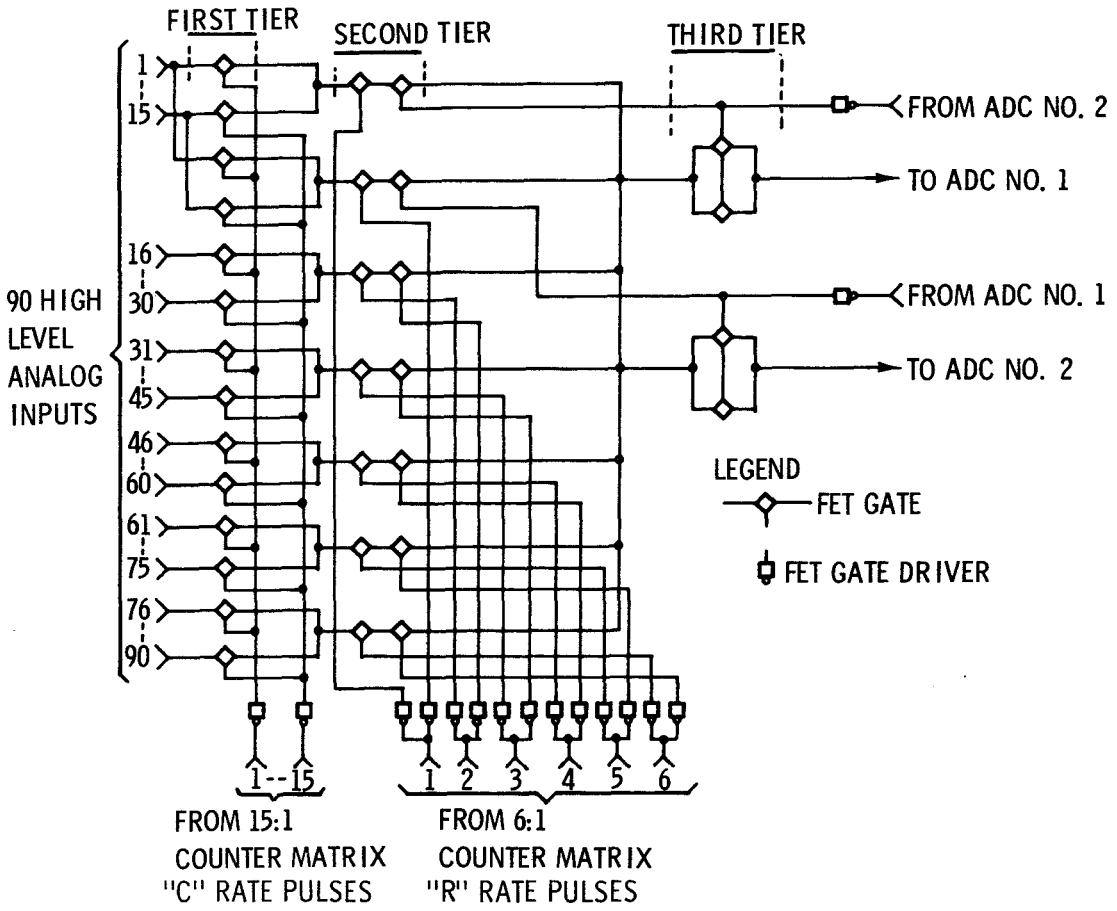
FEB 69 2601 7.56

SIMPLIFIED BLOCK DIAGRAM



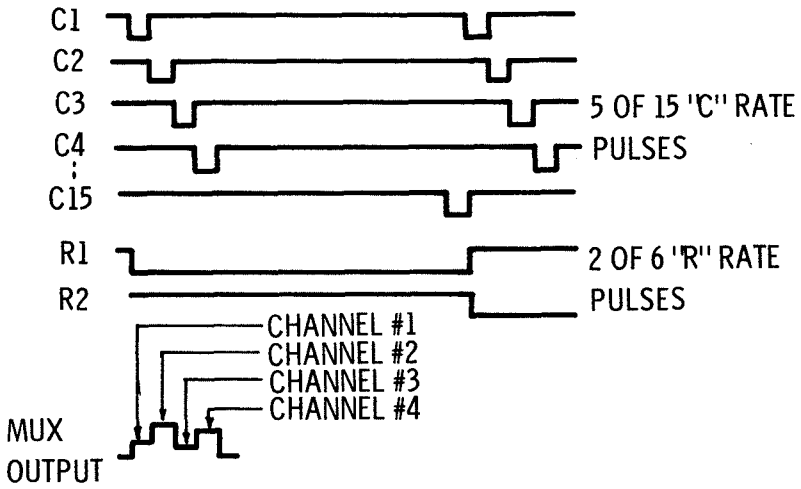
FEB 69 2601 7.57

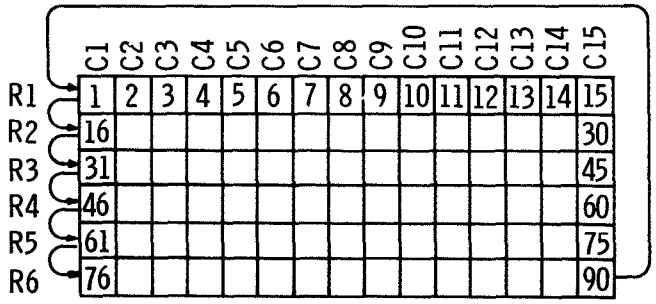
MULTIPLEXER GATE ARRANGEMENT DIAGRAM



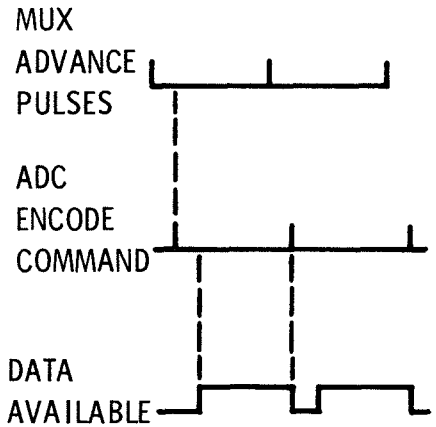
FEB 69 2601 7.58

MULTIPLEXER TIMING DIAGRAM



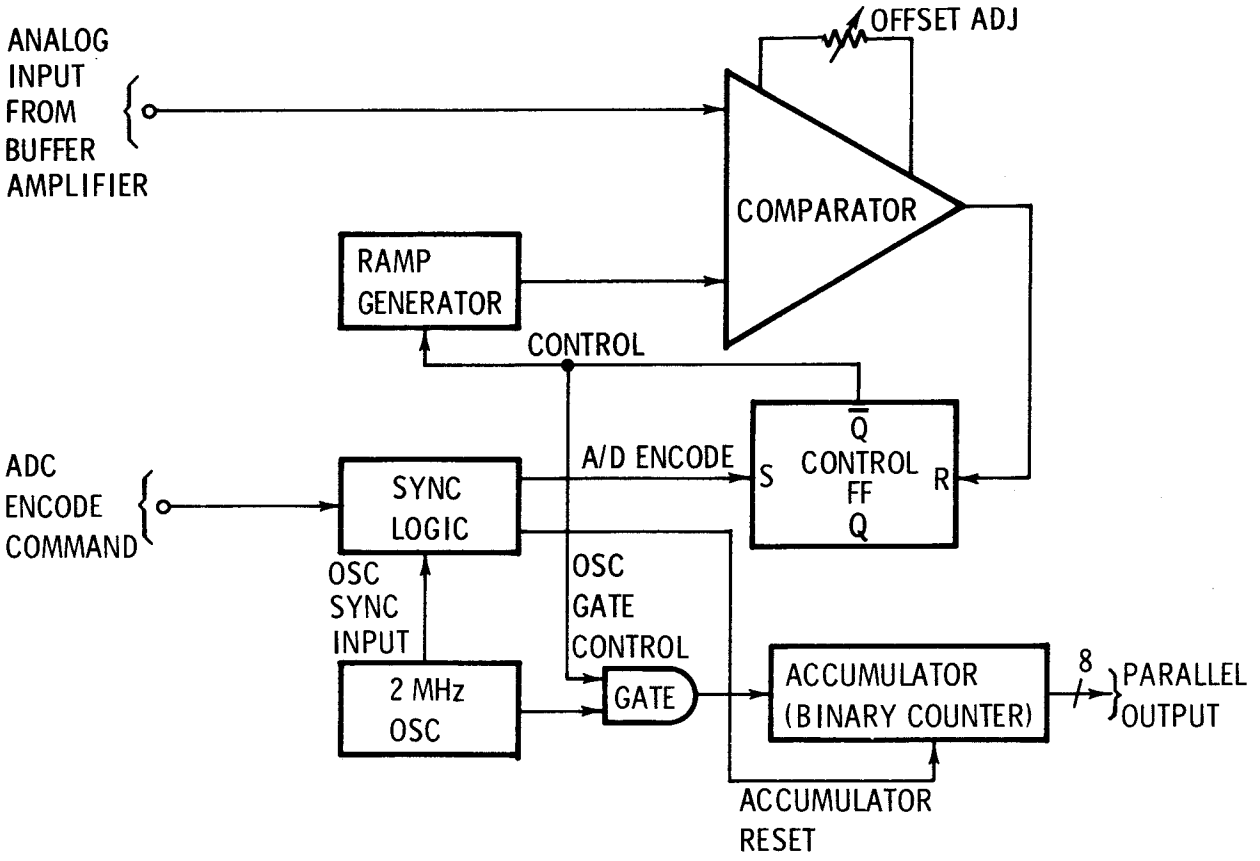


DATA FORMAT AND
CHANNEL SEQUENCE



FEB 69 2601 7.59

A/D CONVERTER FUNCTIONAL BLOCK DIAGRAM



FEB 69 2601 7.60

INPUT REQUIREMENTS

ANALOG INPUTS

RANGE	0 TO +5 volts
INPUT Z	≧ 1 megohm (ON state)
	≧50 megohms (OFF state)
SOURCE Z	≦ 10 k ohms

*PROPER OPERATION WITH AN OVERVOLTAGE OF

+8 to -6.5 volts for channels 21, 36, 45, & 80.
+8 to -9 volts for channels 6, 7, 26, 52, 67, & 70.
+8 to -5 volts for all other channels.

IS NOT DAMAGED BY AND OVERVOLTAGE OF ± 12 VOLTS ON ANY CHANNEL.

ADVANCE PULSE

REQUIRED FOR ADVANCING MULTIPLEXER THROUGH ITS 90 CHANNELS.
SUPPLIED BY DDP.

ADC START (ENCODE) PULSE

DRIVES SYNC LOGIC TO START A/D CONVERSION. SUPPLIED BY DDP.

*PROPER OPERATION IS NOT GUARANTEED BEYOND PLUS AND MINUS OPERATIONAL LIMITS.

ANALOG MULTIPLEXER/CONVERTER OUTPUTS

BINARY OUTPUT -

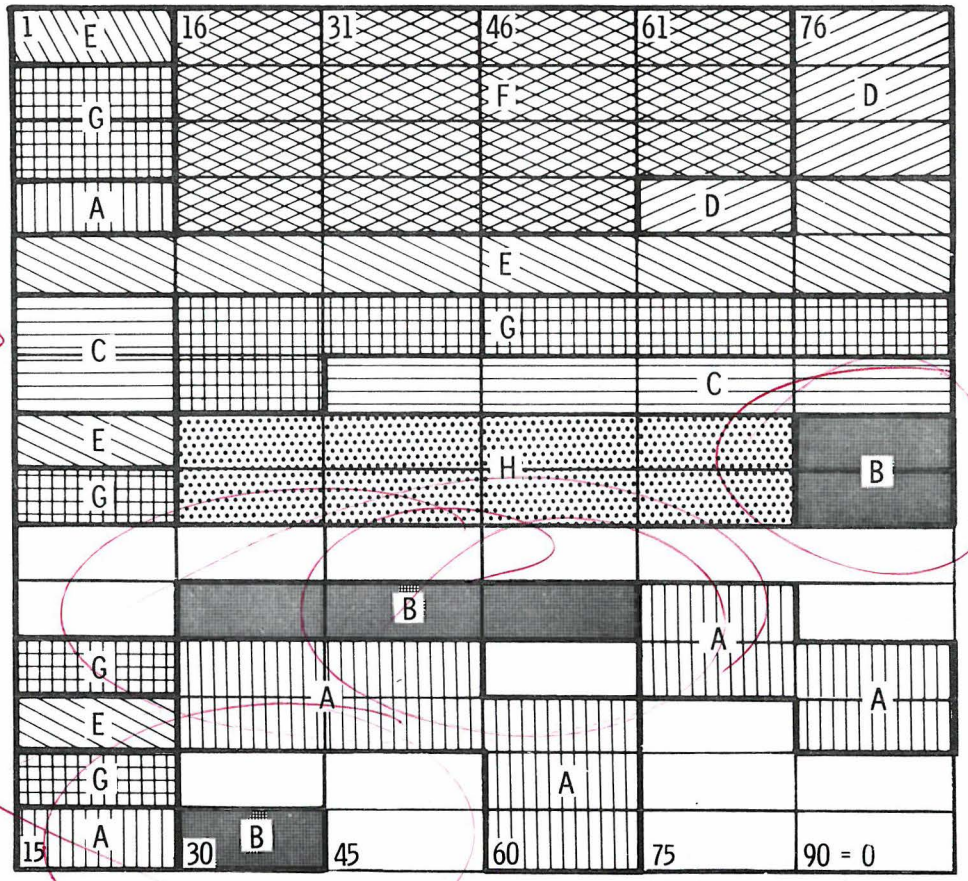
00000000	FOR A NEGATIVE INPUT
00000001	FOR ZERO INPUT
11111110	FOR +5 VOLTS INPUT
11111111	FOR GREATER THAN +5 VOLTS INPUT

LOGICAL "0" IS +4.0 ±1.5 volts
LOGICAL "1" IS +0.2 ± 0.2 volts

TEMPERATURE TELEMETRY

CHANNEL 33	AT-27	BASE TEMP (SIGNAL OBTAINED BY A THERMISTOR/ RESISTOR NETWORK POWERED BY +12 VDC THERMISTOR LOCATED ON BASE PLATE)
CHANNEL 34	AT-28	INTERNAL TEMP (SAME AS ABOVE EXCEPT THERMISTOR MOUNTED ON PCB)

ANALOG MULTIPLEXER CHANNEL ASSIGNMENTS

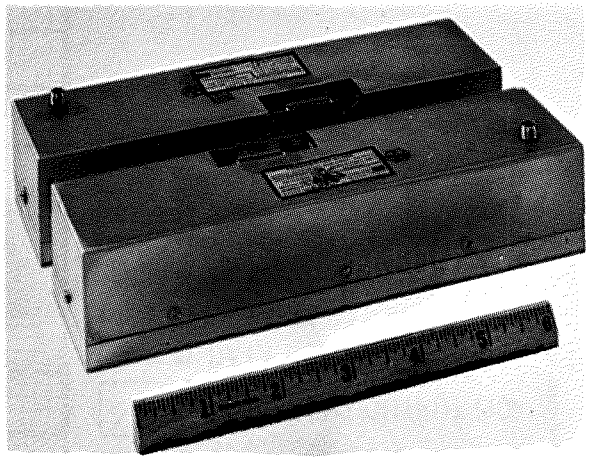


- A — STRUCTURE & INSULATION TEMPERATURES (13)
- B — DUST CELLS (6)
- C — FIXED BRIDGE OUTPUTS (6)
- D — PCU TEMPERATURES (4)
- E — PCU INPUT/OUTPUT (10)
- F — DATA SUBSYSTEM TEMPERATURES (15)
- G — DATA SUBSYSTEM FUNCTIONAL (11)
- H — PSE (8)

APPEARS IN WORD 33 ON PSEP 1

FEB 69 2601 7.63

TRANSMITTER



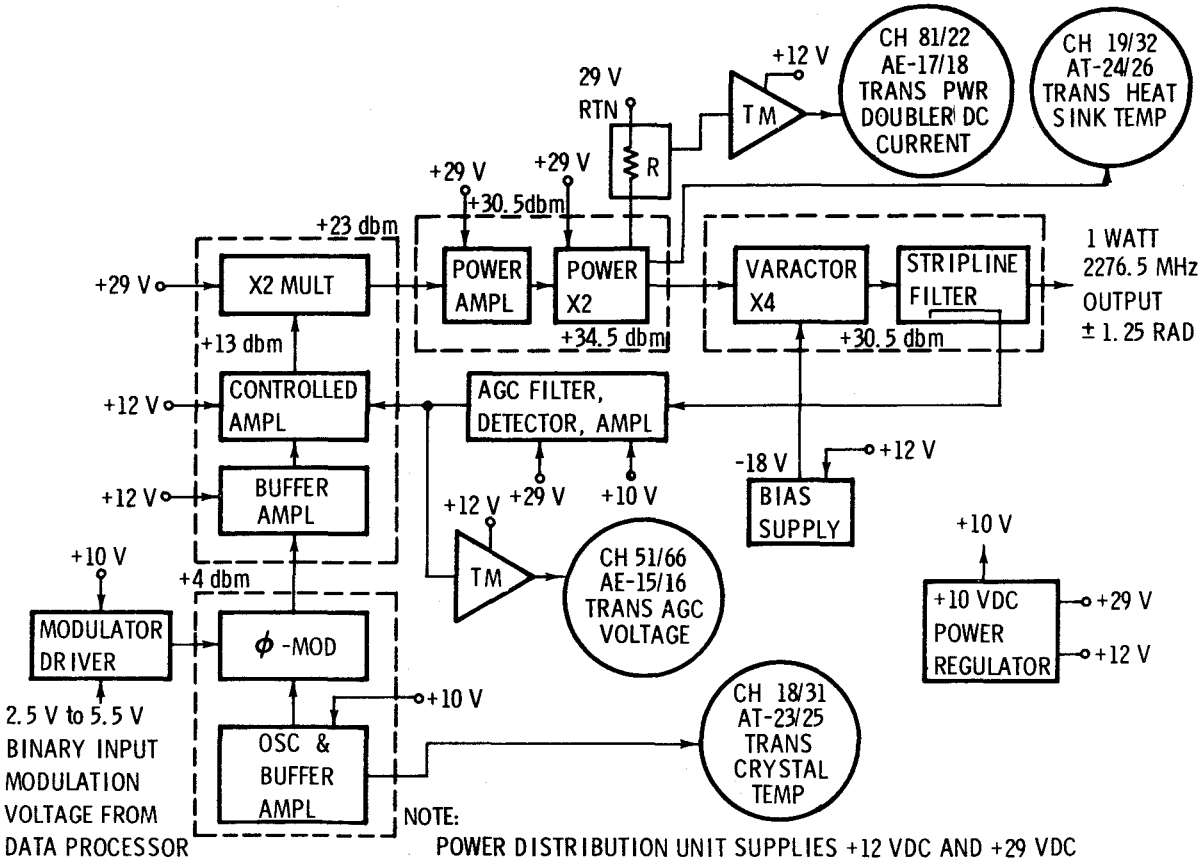
* FREQUENCY 2276.5 MHz ± 0.0025%/YEAR
* PROVIDES A MINIMUM OF 1 WATT INTO A 50 OHM LOAD WITH A MAXIMUM VSWR OF 1.3:1
* TWO IDENTICAL COMPONENTS, TRANS A AND TRANS B, ARE PROVIDED WITH ONE IN STANDBY
* EITHER A OR B MAY BE SELECTED BY COMMAND FROM THE MSFN
* IF ONE IS SWITCHED "OFF" DUE TO AN OVERCURRENT CONDITION, THE OTHER IS AUTOMATICALLY SWITCHED "ON"

TRANSMITTER

PHYSICAL DESCRIPTION

- SIZE 1.5 x 2 x 7.5 inches
- WEIGHT 1.17 pounds (each)
- POWER 8 watts at 29 VDC
  0.5 watts at 12 VDC
- EMPLOYS MODULAR CONSTRUCTION WITH 11 SEPARATE CIRCUIT MODULES
- MODULES ARE MOUNTED ON A MILLED MAGNESIUM BASE PLATE WITH INTER-MODULE WIRING THROUGH MILLED PASSAGEWAYS

TRANSMITTER, BLOCK DIAGRAM



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TRANSMITTER
TELEMETRY SUMMARY

TRANSMITTER A		TELEMETRY DATA	TRANSMITTER B	
CHANNEL	SYMBOL		CHANNEL	SYMBOL
18	AT-23	TRANSMITTER CRYSTAL TEMP USES A 15 K OHM THERMISTOR AND 2 RESISTORS TO DEVELOP SIGNAL. PARTS ARE LOCATED IN OSC. -BUFFER- MODULATOR MODULE.	31	AT-25
19	AT-24	TRANSMITTER HEAT SINK TEMP USES A 15 K OHM THERMISTOR AND 2 RESISTORS TO DEVELOP SIGNAL. LOCATED IN POWER DOUBLER.	32	AT-26
51	AE-51	TRANS AGC VOLTAGE AGC VOLTAGE IS AMPLIFIED TO GIVE TM SIGNAL OF PROPER LEVEL.	66	AE-16
81	AE-17	TRANS PWR DOUBLER DC CURRENT SIGNAL OBTAINED FROM SMALL RE- SISTOR IN POWER RETURN.	22	AE-18

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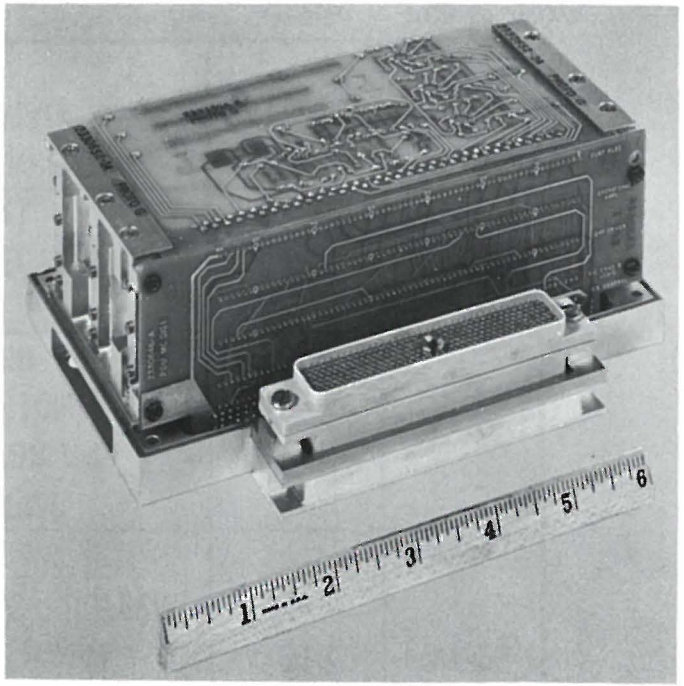
POWER DISTRIBUTION UNIT



- PROVIDES FOR THE DISTRIBUTION AND CONTROL OF POWER TO DATA SUBSYSTEM ELECTRONIC COMPONENTS AND THE PSE SUBSYSTEM
- CONTAINS CIRCUITRY TO PROTECT THE SYSTEM AGAINST OVER-LOADS OCCURRING FROM COMPONENT FAILURES
- PROVIDES SIGNAL CONDITIONING FOR CENT STA AND POWER SUBSYSTEM TELEMETRY SIGNALS
- PROVIDES MOUNTING SPACE FOR THE "DUST DETECTOR" ELECTRONICS.

FEB 69 2601 7.68

POWER DISTRIBUTION UNIT

PHYSICAL DESCRIPTION OF THE PDU

* SIZE 2.8 x 4 x 7.25 inches
* WEIGHT 2.29 pounds
* POWER 375 milliwatts at +29 VDC
  75 milliwatts at +15 VDC
  735 milliwatts at +12 VDC
  85 milliwatts at + 5 VDC
  8 milliwatts at - 6 VDC
  475 milliwatts at -12 VDC
* PARTS COUNT - 17 FLATPACKS 238 RESISTORS
  37 TRANSISTORS 44 CAPACITORS
  11 AMPLIFIERS 7 FUSES
  98 DIODES 2 THERMISTORS
  27 RELAYS
* PACKAGING - ALL PARTS ARE MOUNTED ON 5 PCBs
* CONNECTOR - HUGHES - 244 PIN

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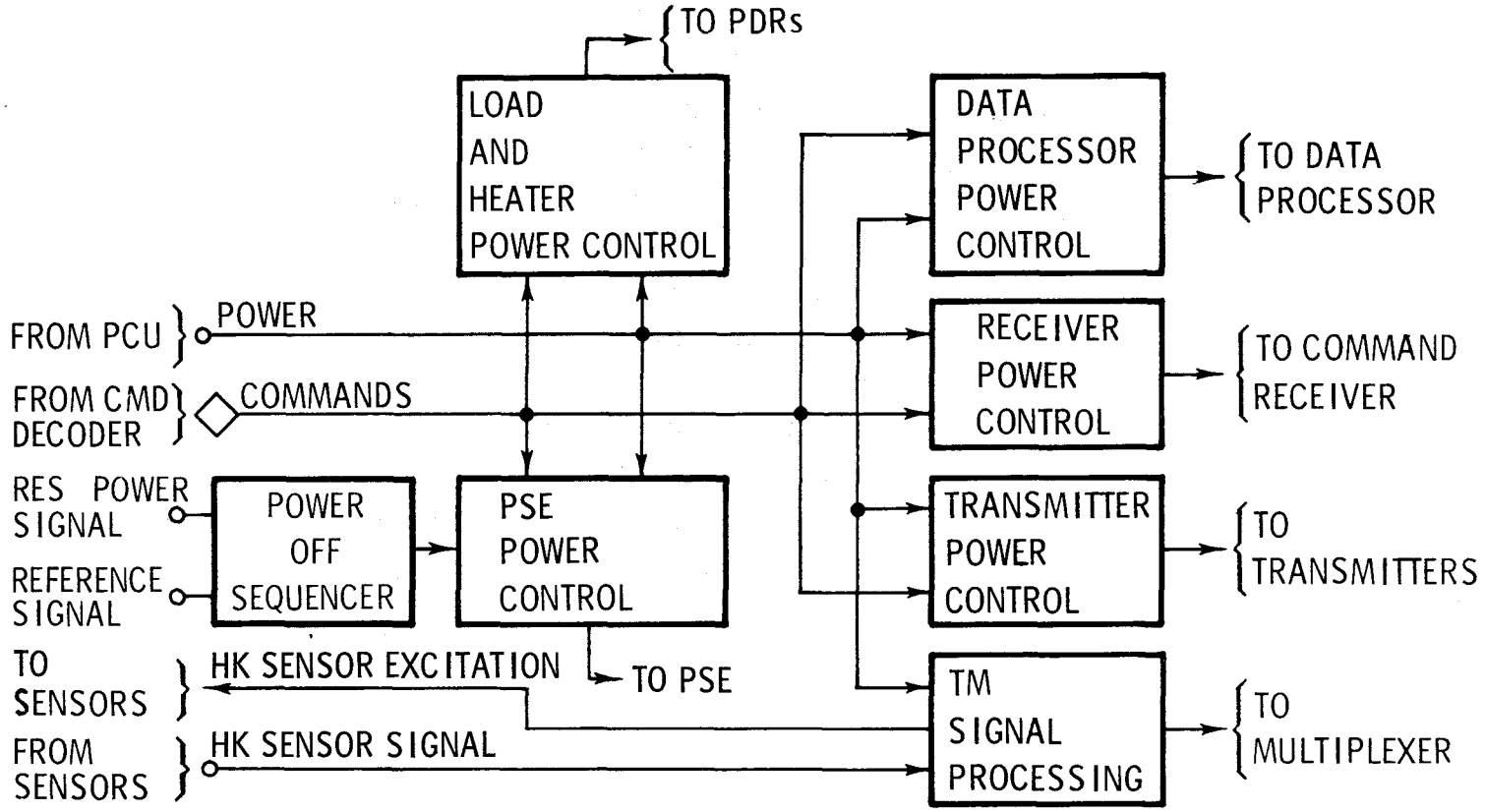
SIMPLIFIED BLOCK DIAGRAM PDU



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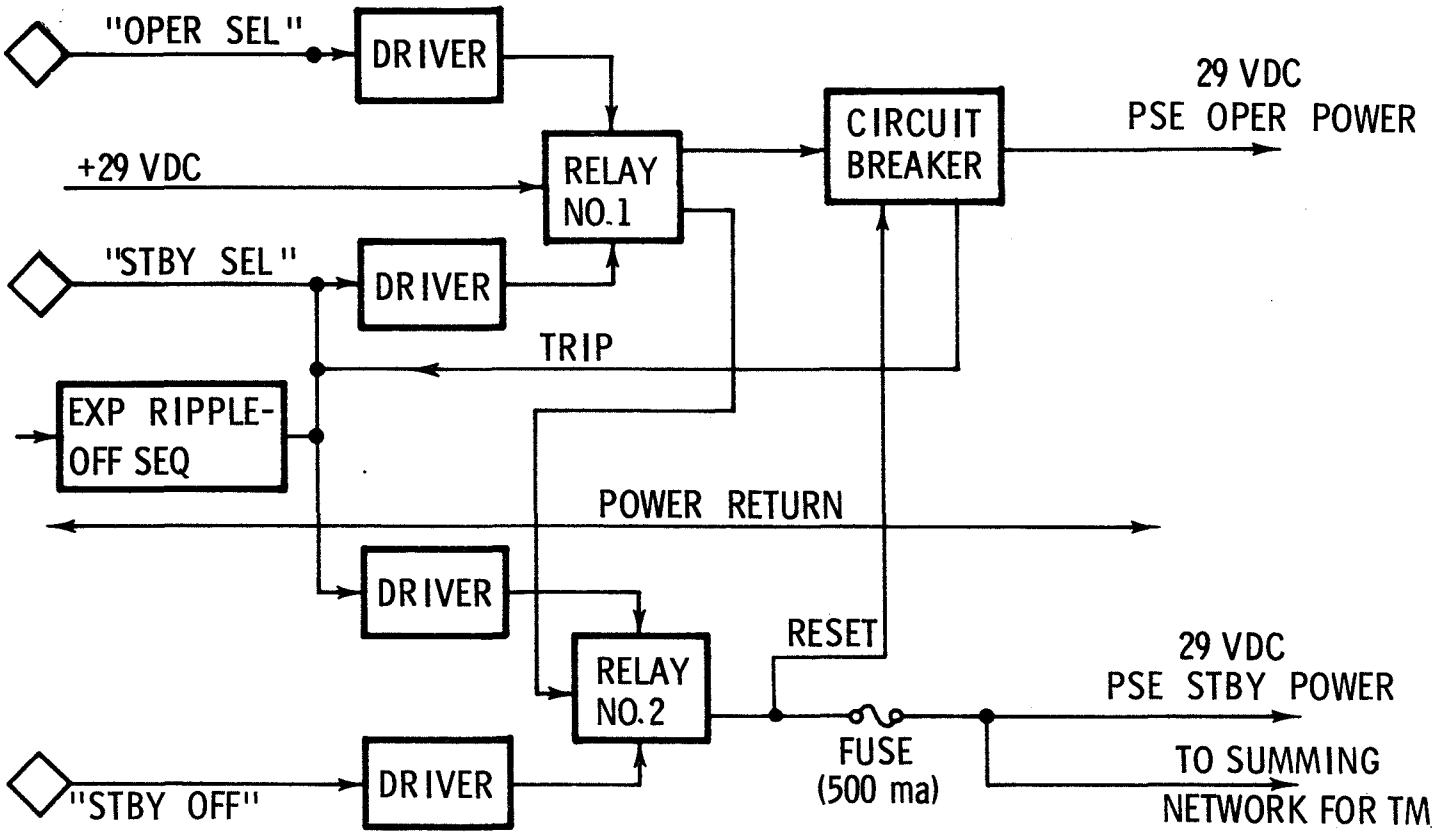
PSE POWER CONTROL



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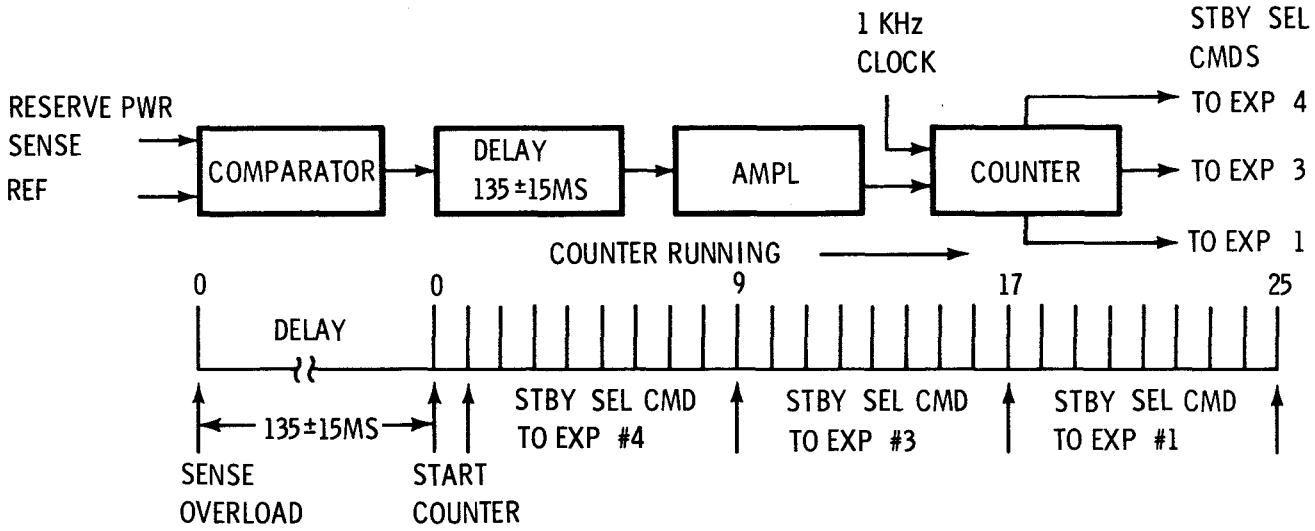
EXPERIMENT RIPPLE-OFF SEQUENCE



* THIS FUNCTION, PROVIDED FOR ALSEP, WILL ONLY AFFECT PSE (EXP 1) BUT THE STATUS OF EXP POWER MODE TM MAY CHANGE AFTER A RIPPLE SEQUENCE.
* IF OVERLOAD CONDITION EXISTS FOR 135 ±15MS, THEN FROM COUNT 1 to COUNT 9 A "STBY SEL" CMD IS ISSUED.
* AFTER 9MS, IF OVERLOAD STILL EXISTS, A "STBY SEL" CMD IS ISSUED FROM COUNT 9 TO COUNT 17.
* IF OVERLOAD STILL EXISTS, A "STBY SEL" CMD IS ISSUED FROM COUNT 17 TO COUNT 25.
* WHEN OVERLOAD IS CLEARED THE COUNTER IS RESET AND FURTHER EXPERIMENT SWITCHING IS INHIBITED.

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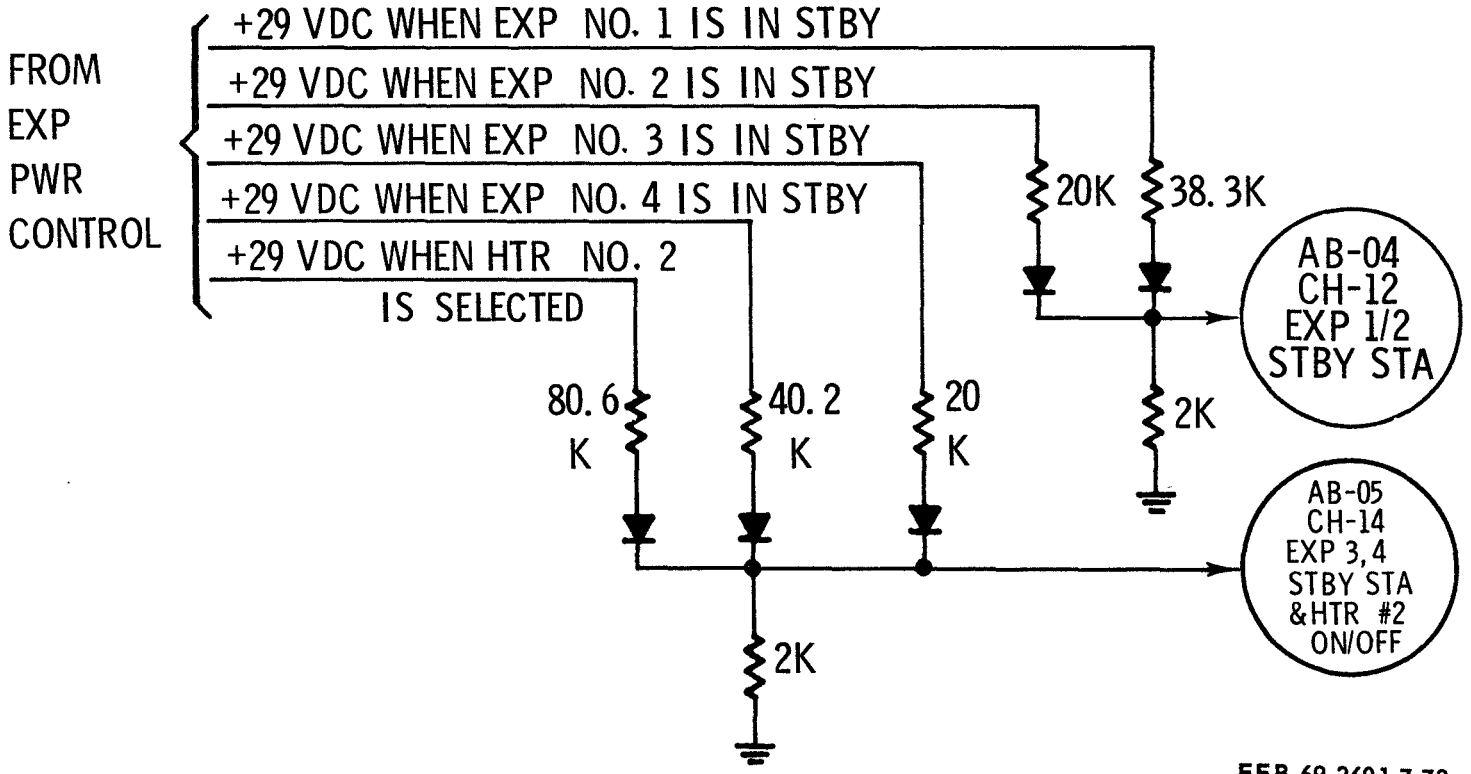
EXP PWR MODE TM



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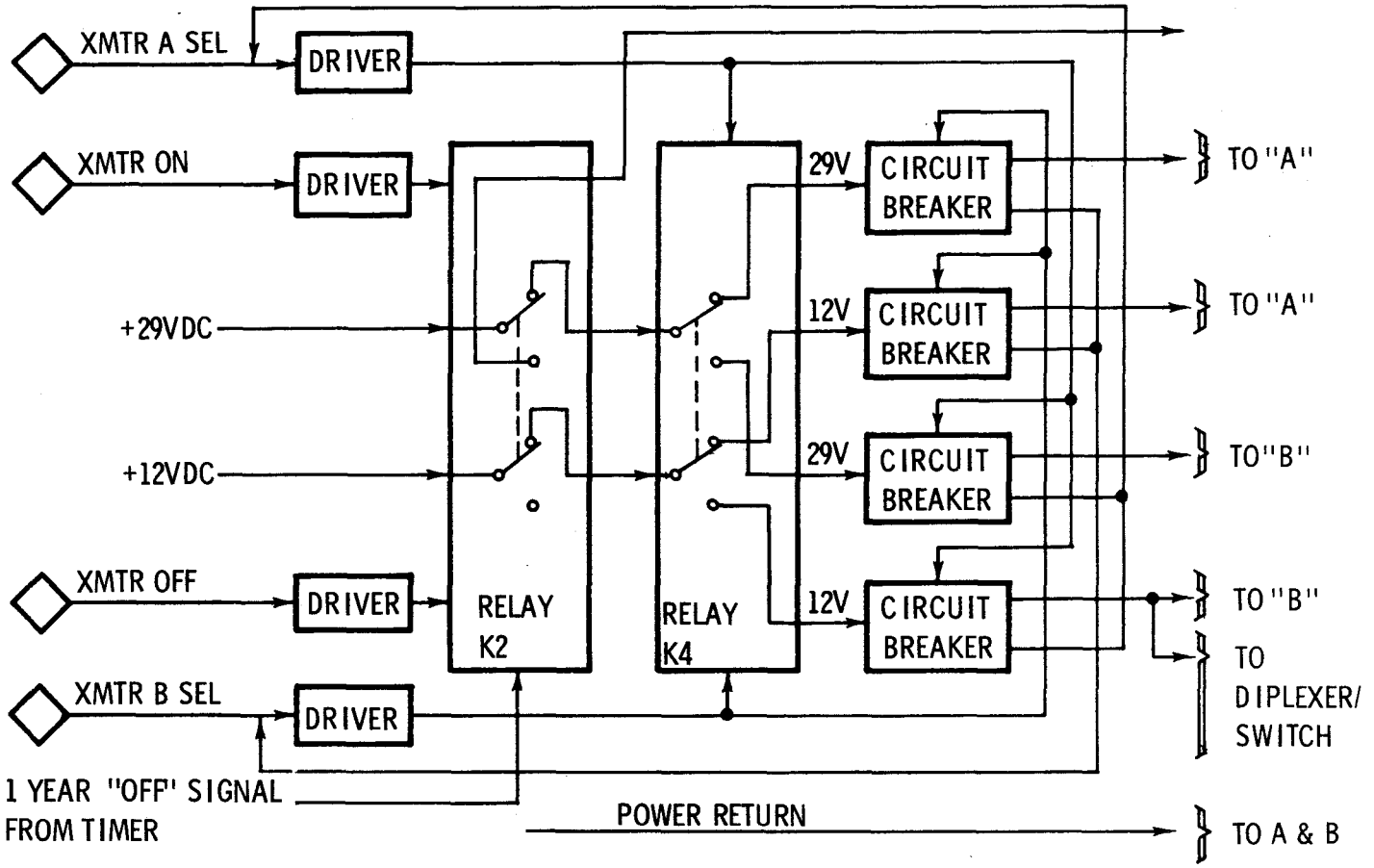
TRANSMITTER POWER CONTROL



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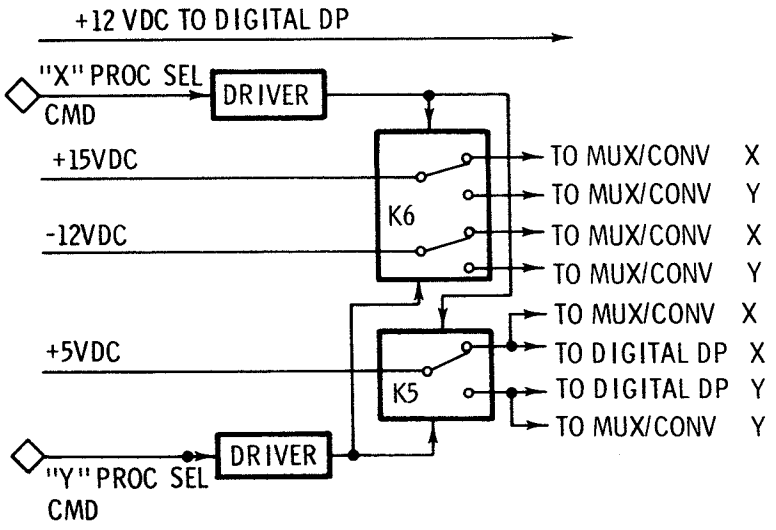
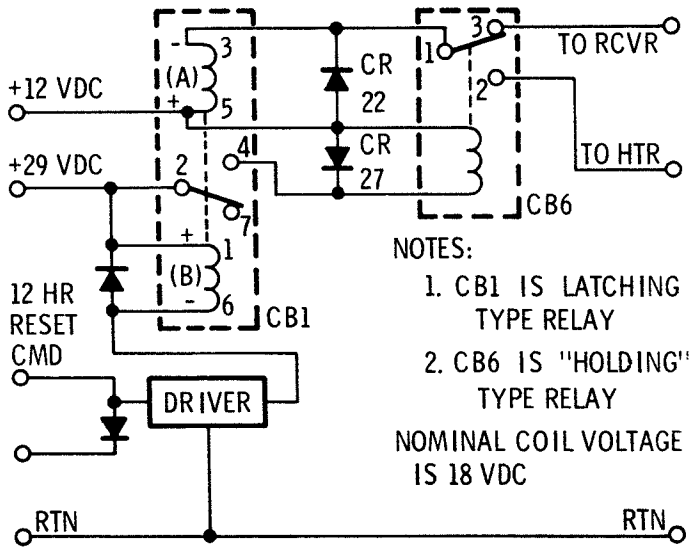
DATA PROCESSOR & CMD RCVR PWR CONTROL CKTS

DATA PROCESSOR



COMMAND RECEIVER



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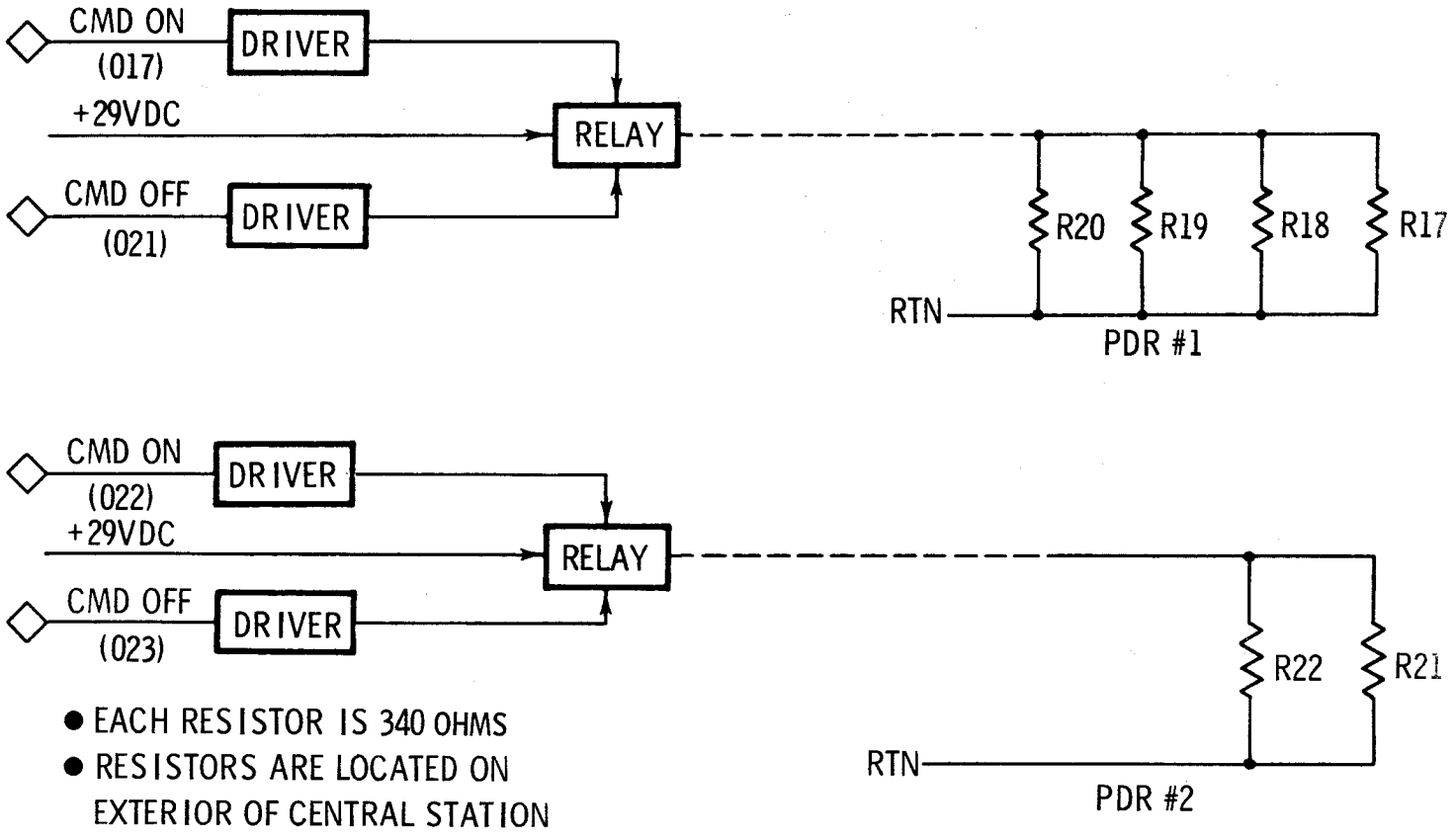
SWITCHING FOR POWER DUMP RESISTORS



- EACH RESISTOR IS 340 OHMS
- RESISTORS ARE LOCATED ON EXTERIOR OF CENTRAL STATION

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TELEMETRY SIGNAL CONDITIONING

THE FOLLOWING SIGNALS ARE OBTAINED FROM THERMISTORS AND RESISTOR DIVIDERS POWERED BY +12VDC. FOR AT-34, THE THERMISTOR IS LOCATED ON THE BASE PLATE AND FOR AT-35 THE THERMISTOR IS LOCATED ON PCB.

CHANNEL 62	AT-34	POWER DISTRIBUTION, BASE TEMP	CIRCUIT NO. 2
CHANNEL 63	AT-35	POWER DISTRIBUTION, INTERNAL TEMP	

THE PDU PROVIDES +12 VOLTS AND ONE 5900 OHM RESISTOR, IN SERIES WITH THE EXTERNALLY LOCATED 2000 OHM NICKEL WIRE SENSOR, FOR EACH OF THE FOLLOWING TM MEASUREMENTS.

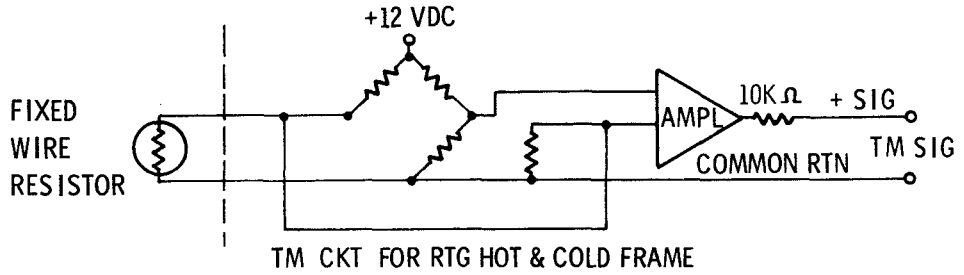
CHANNEL 27	AT-01	ARRAY TEMP-EAST SIDE
CHANNEL 42	AT-02	ARRAY TEMP-WEST SIDE
CHANNEL 59	AT-08	LEFT SIDE STRUCTURE TEMP W1
CHANNEL 87	AT-09	RIGHT SIDE STRUCTURE TEMP W2
CHANNEL 15	AT-10	BOTTOM STRUCTURE TEMP B1
CHANNEL 88	AT-11	BACK STRUCTURE TEMP W3
CHANNEL 60	AT-12	INSULATION INNER TEMP
CHANNEL 72	AT-13	INSULATION OUTER TEMP

THE PDU PROVIDES THE +12 VOLT SUPPLY AND ONE 3010 OHM SERIES RESISTOR FOR EACH OF THE FOLLOWING TM MEASUREMENTS.

CHANNEL 04	AT-03	THERMAL PLATE 1
CHANNEL 28	AT-04	THERMAL PLATE 2
CHANNEL 43	AT-05	THERMAL PLATE 3
CHANNEL 58	AT-06	THERMAL PLATE 4
CHANNEL 71	AT-07	THERMAL PLATE 5
CHANNEL 48	AT-31	COMMAND DECODER BASE TEMP
CHANNEL 49	AT-32	COMMAND DECODER INTERNAL TEMP
CHANNEL 61	AT-33	COMMAND DEMODULATOR, VCO TEMP
CHANNEL 46	AT-29	DIGITAL DP, BASE TEMP
CHANNEL 47	AT-30	DIGITAL DP, INTERNAL TEMP

PDU TELEMETRY CIRCUITS

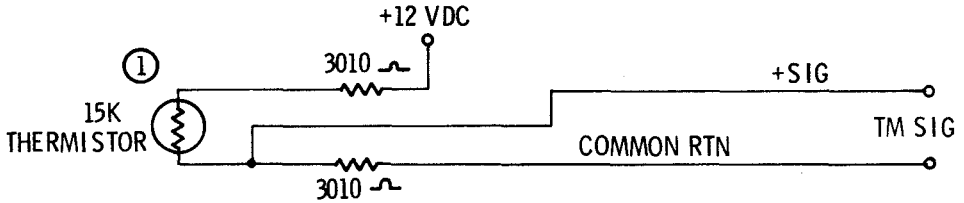
CIRCUIT NO. 1



TM CKT FOR RTG HOT & COLD FRAME

MEASUREMENT	
AR-01	AR-04
AR-02	AR-05
AR-03	AR-06

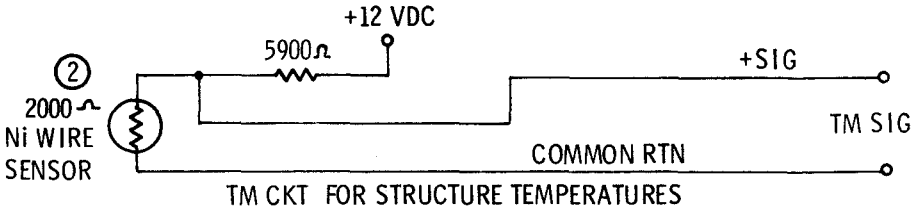
CIRCUIT NO. 2



TM CKT "INTERNAL" TEMPERATURES

AT-03 THRU AT-07
AT-29 THRU AT-35

CIRCUIT NO. 3



TM CKT FOR STRUCTURE TEMPERATURES

AT-01	AT-08
AT-02	AT-09
	AT-10
	AT-11
	AT-12
	AT-13

① FENWAL ISO-CURVE THERMISTOR - 15K OHMS
② TYLAN FG-108 NICKEL WIRE SENSOR - 2000 OHMS

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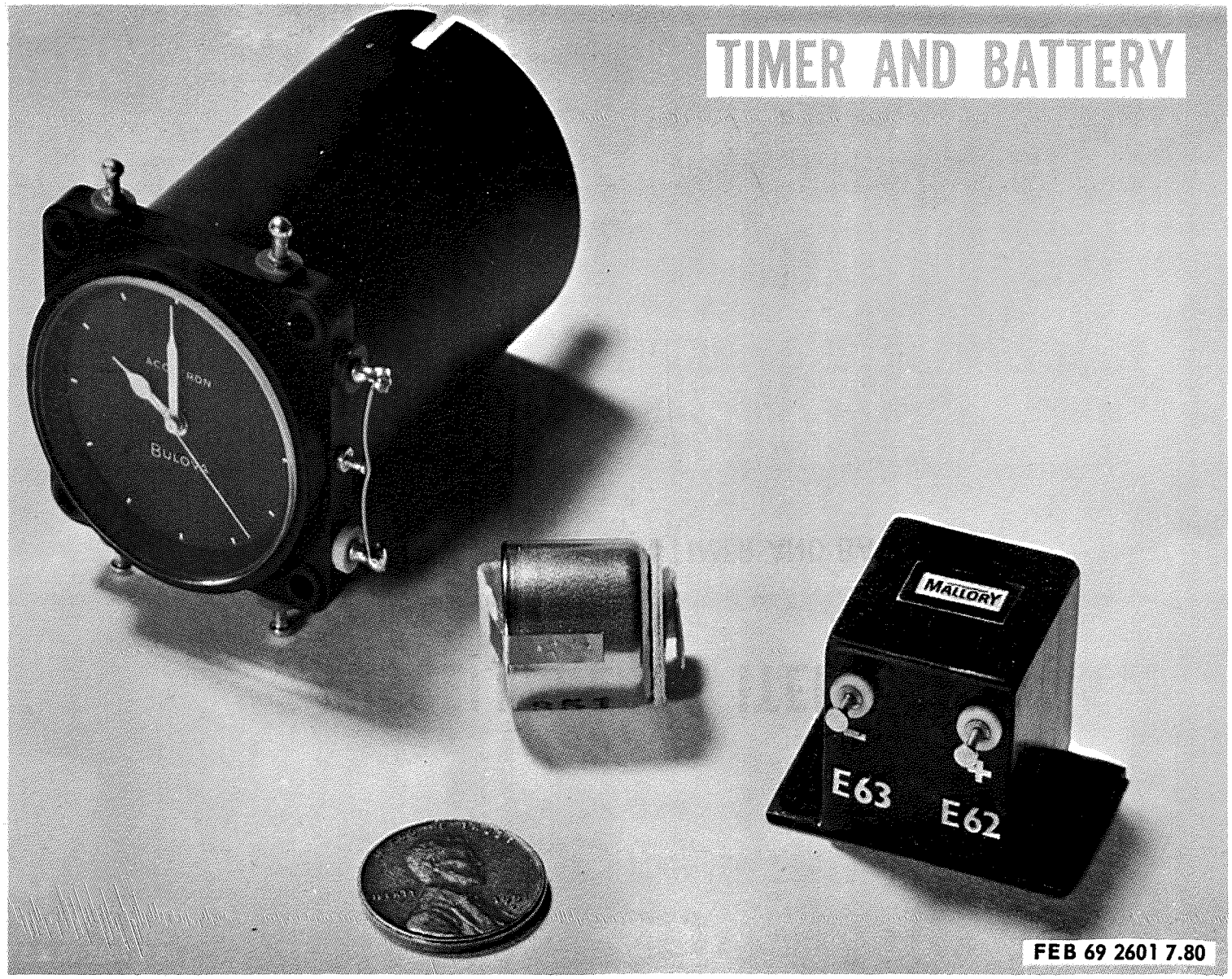
MISCELLANEOUS ITEMS

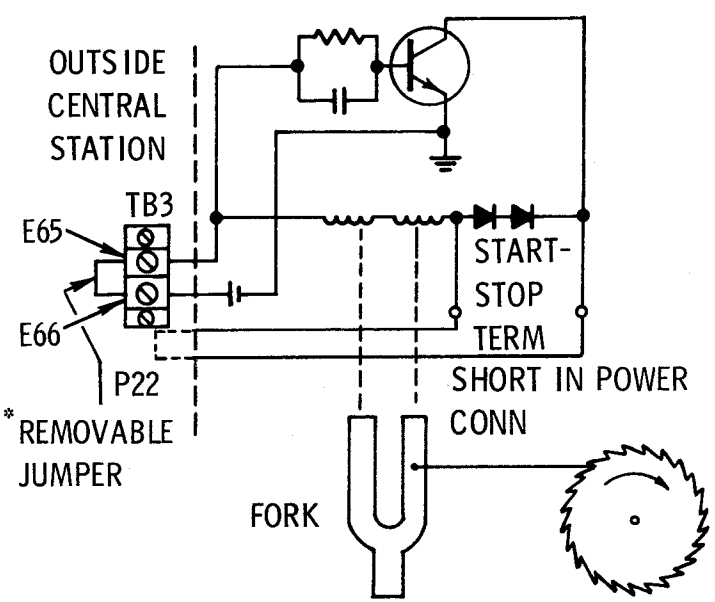
- CENTRAL STATION TIMER AND BATTERY
- WIRE HARNESS


TIMER AND BATTERY
MALLORY
E63
E62
FEB 69 2601 7.80

CENTRAL STATION TIMER

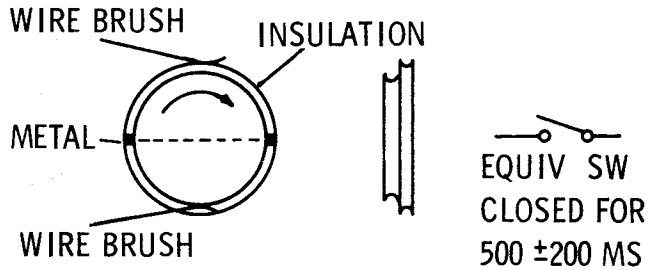
- THE CST IS AN ACCUTRON MECHANISM OBTAINED FROM THE BULOVA WATCH CO.
- A TUNING FORK IS USED TO ACCURATELY CONTROL SWITCH CLOSURE TIME.
- SIZE: 1.32 x 1.32 x 2.63 INCHES
- WEIGHT: 0.265 POUNDS
- POWER IS PROVIDED BY A SEPARATE BATTERY
- TWO MODES OF OPERATION ARE PROVIDED-
  - "STOP MODE" - POWER IS APPLIED AND FORK IS OSCILLATING AT LOW LEVEL - ROTARY MOTION IS NOT PRODUCED. MAXIMUM CURRENT IS 7 MICROAMPERES. THIS MODE IS USED FROM FINAL TEST UNTIL DEPLOYMENT ON THE LUNAR SURFACE.
  - "START MODE" - ADDITIONAL POWER IS APPLIED FOR INCREASED AMPLITUDE OF FORK OSCILLATION. ROTARY MOTION IS PRODUCED TO DRIVE THE SWITCH MECHANISM. MAXIMUM CURRENT IS 12 MICROAMPERES.

CENTRAL STA TIMER MECHANISM



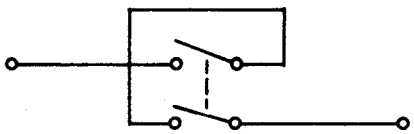
*JUMPER IS REMOVED AND 360 Hz SIGNAL APPLIED TO START FORK.

1 MIN SW ACTION PRODUCED
BY SINGLE SEGMENT COMMUTATOR



12 HR SWITCH IS PRODUCED
SNAP ACTION MECHANISM

XMTR "OFF" SWITCH



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CENT STA TIMER BATTERY

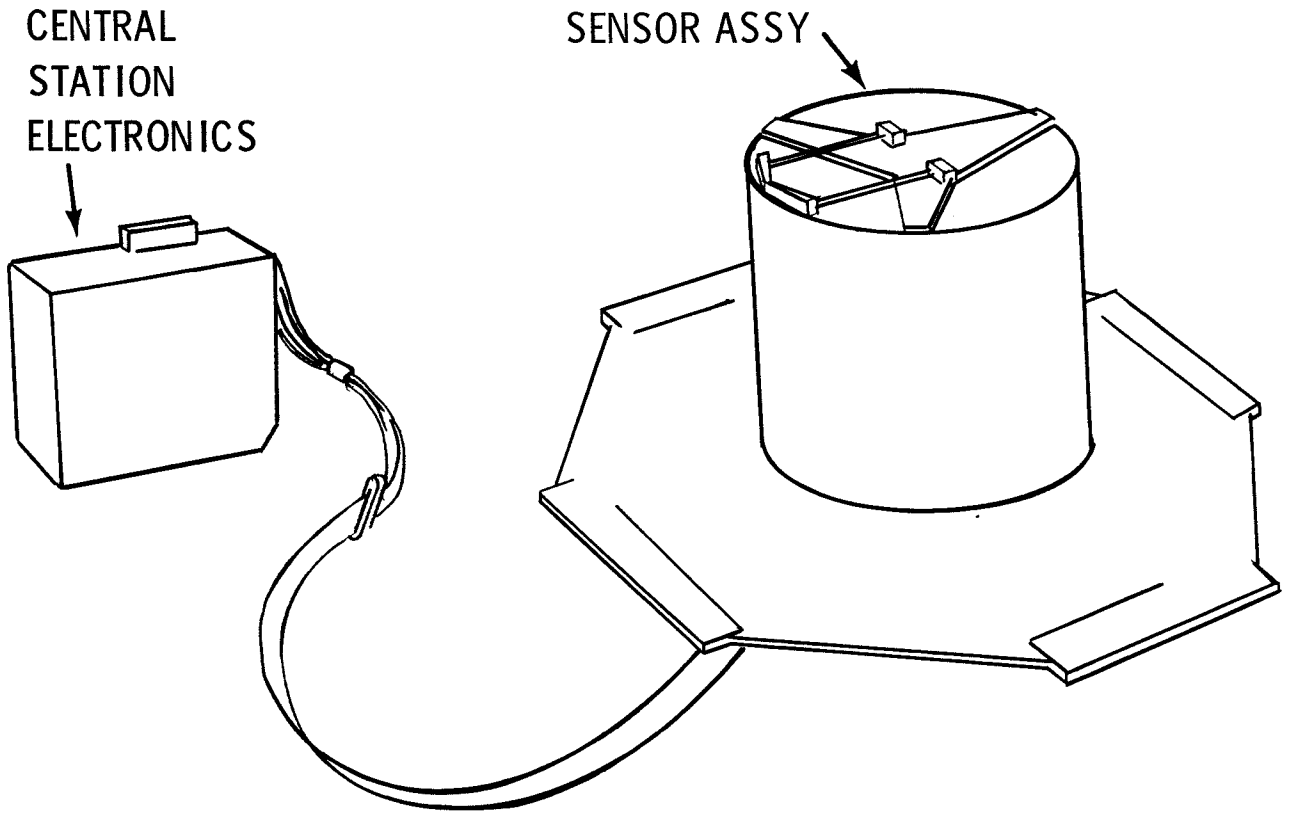
- CONSISTS OF A P.R. MALLORY ZINC-MERCURIC-OXIDE, TYPE RMCC1W CELL, IN A SPECIAL PACKAGE FOR PSEP. BASIC CELL IS CALLED "PACER".
- INITIAL TERMINAL VOLTAGE IS 1.5 VOLTS MAXIMUM
- MINIMUM CELL CAPACITY IS 750 MILLIAMPERE HOURS
- CELL CAPACITY IS DERATED TO 375 MILLIAMPERE HOURS FOR PSEP
- CELL CAPACITY IS GUARANTEED AFTER STORAGE (OPEN CIRCUIT) FOR UP TO 2 YEARS.
- OPERATING TEMPERATURE IS -65 to +162^{0}F.

WIRE HARNESS

- ALL COMPONENTS ARE INTERCONNECTED WITH A PRE-FORMED WIRE HARNESS WHICH PROVIDES THE PROPER MATING PLUGS.
- WITHIN THE THERMALLY CONTROLLED AREA, AWG# 24 SINGLE CONDUCTOR, STRANDED, COPPER WIRE IS USED.
- TWO PRINTED CIRCUIT TERMINAL BOARDS ARE USED TO PERMIT TRANSITION FROM COPPER TO MANGANIN FOR WIRES WHICH MUST GO OUTSIDE THE THERMALLY CONTROLLED AREA.
- TO REDUCE THERMAL CONDUCTION, MANGANIN WIRE, WHICH HAS A THERMAL CONDUCTIVITY ABOUT 1/17 THAT OF COPPER, IS USED BETWEEN THE PC TERMINAL BOARDS AND EXTERNAL INTERFACES (CONNECTORS).
- CONNECTORS USED ARE MADE BY HUGHES, SCHJELDAHL, DEUTSCH AND MICRODOT.

PASSIVE SEISMIC EXPERIMENT

- COMPONENTS & FUNCTION
- COMMANDS & DATA



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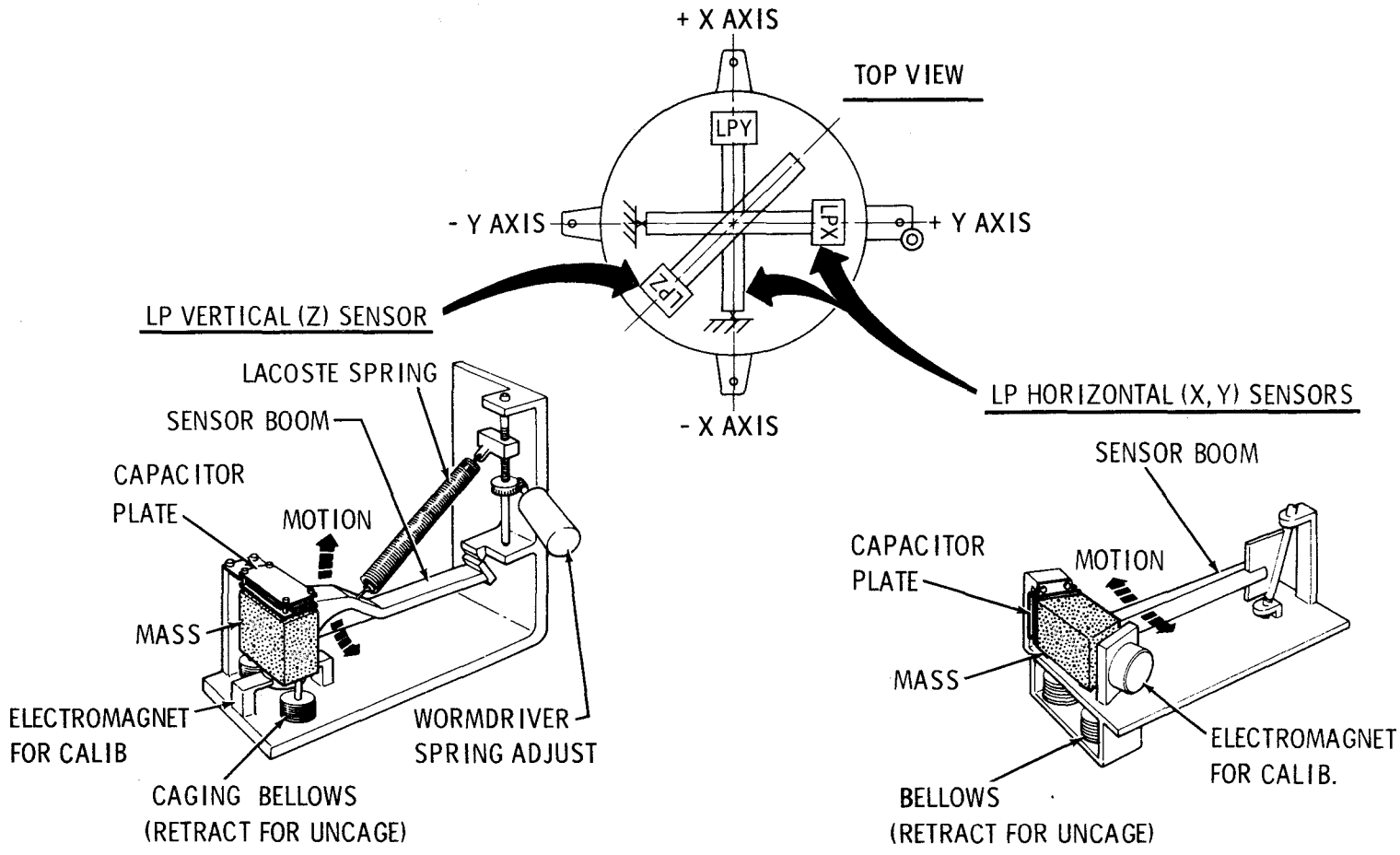
INSTRUMENT DETAILS



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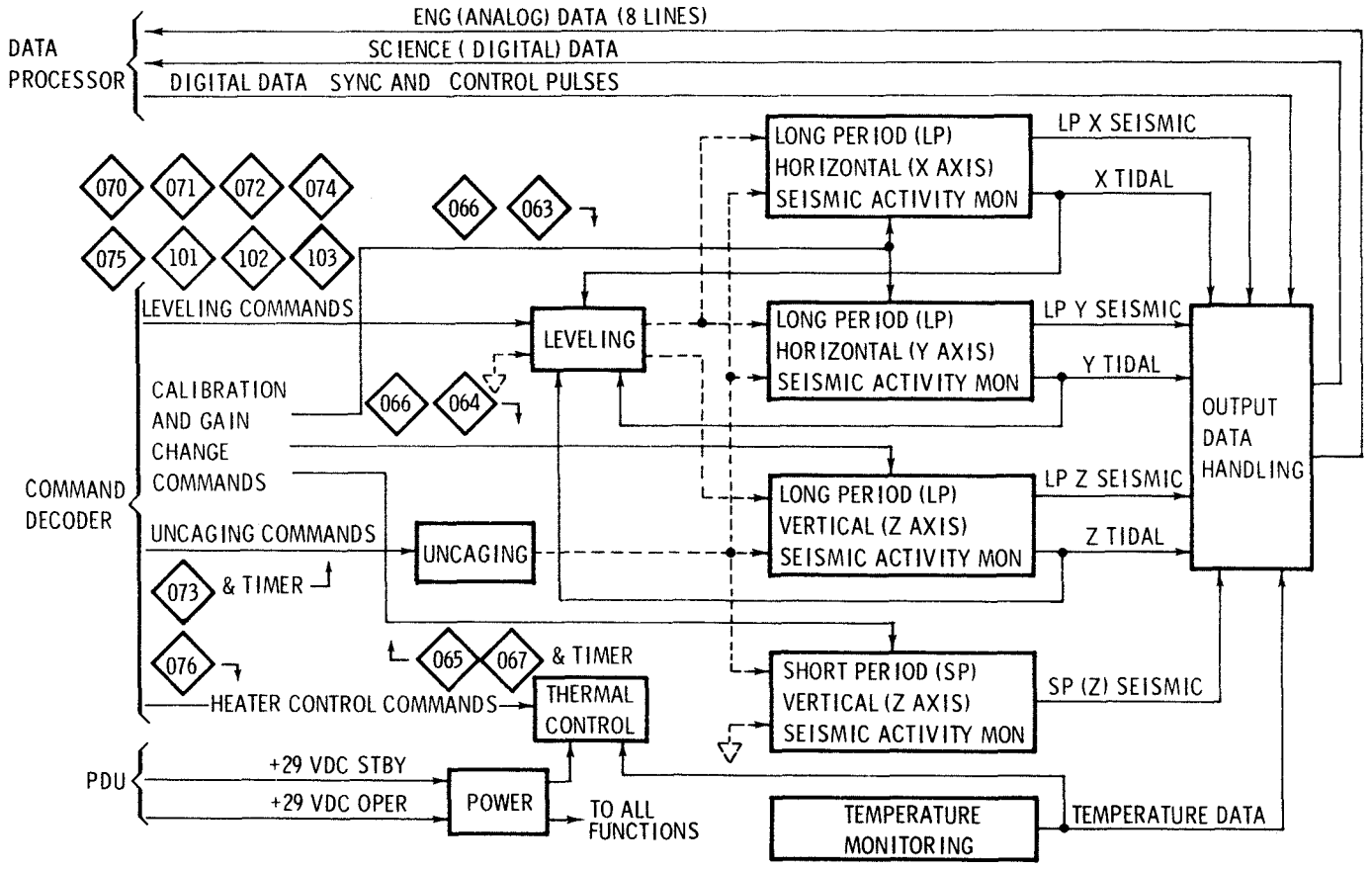
PSE FUNCTIONAL BLOCK DIAGRAM



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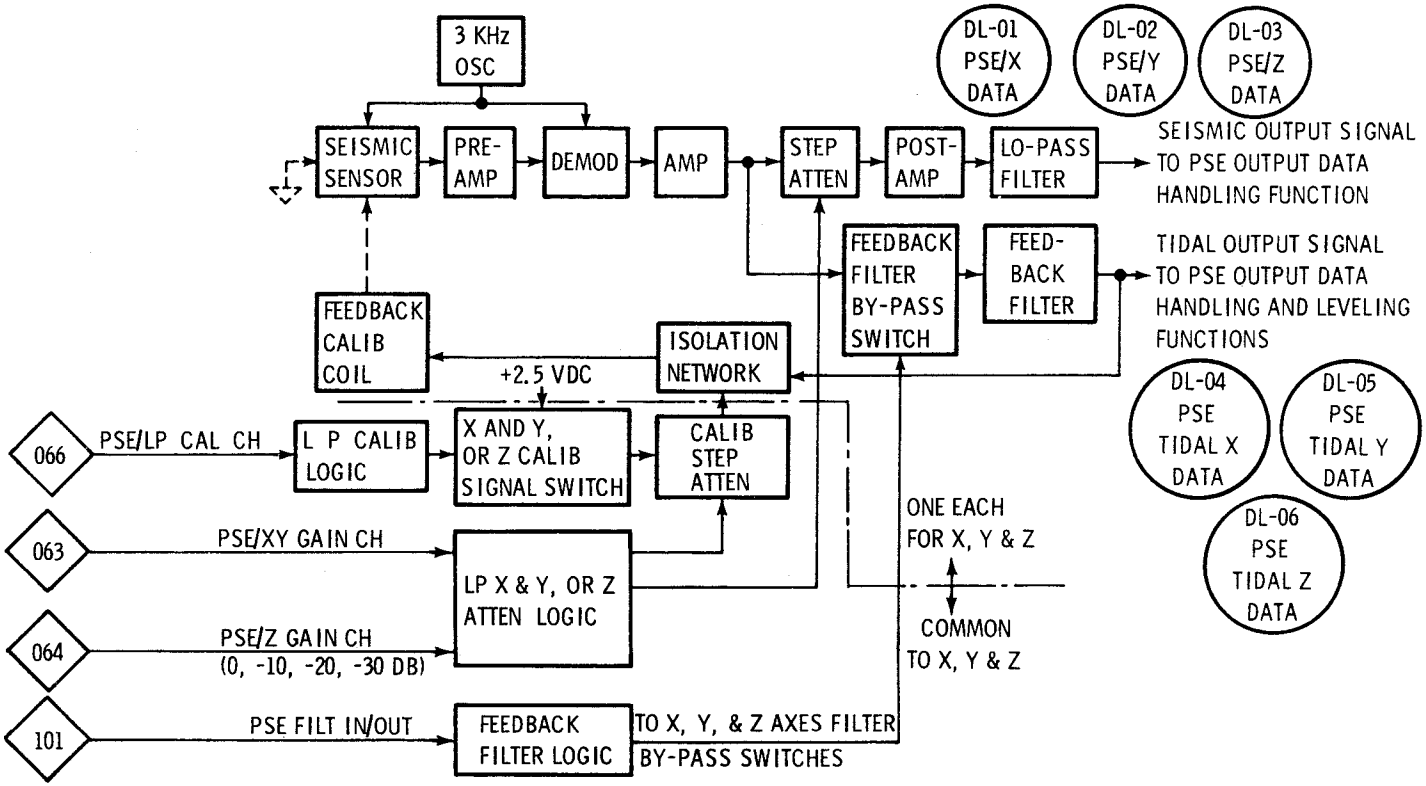
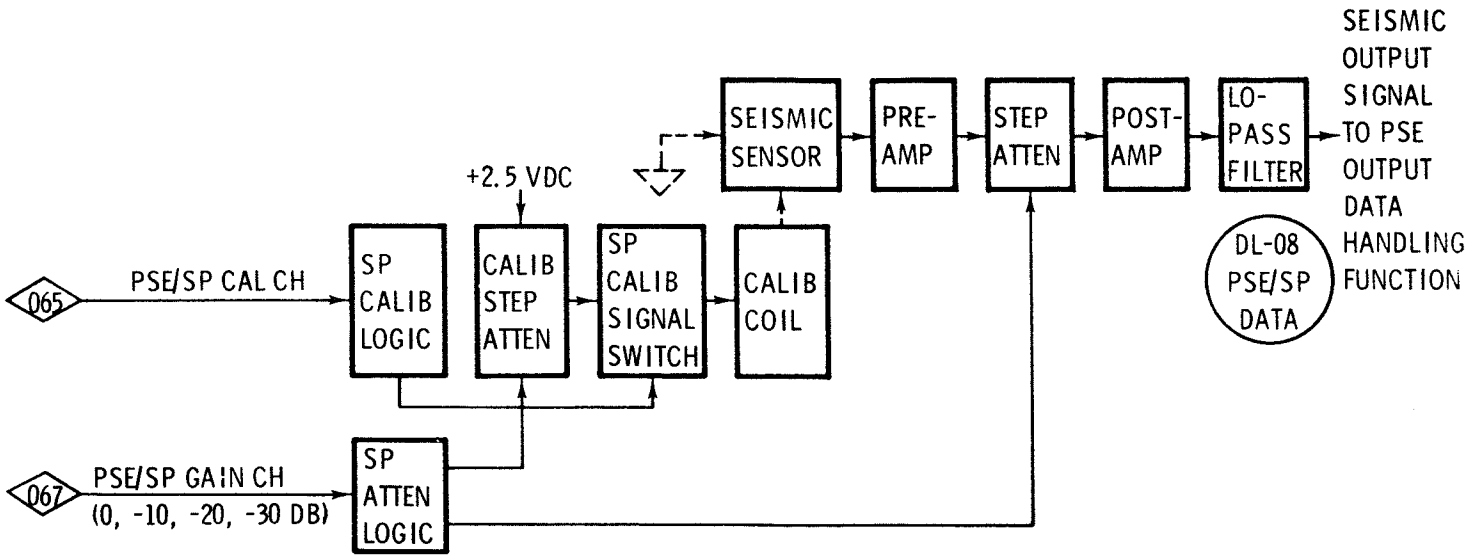
LONG PERIOD (LP) SEISMIC FUNCTION



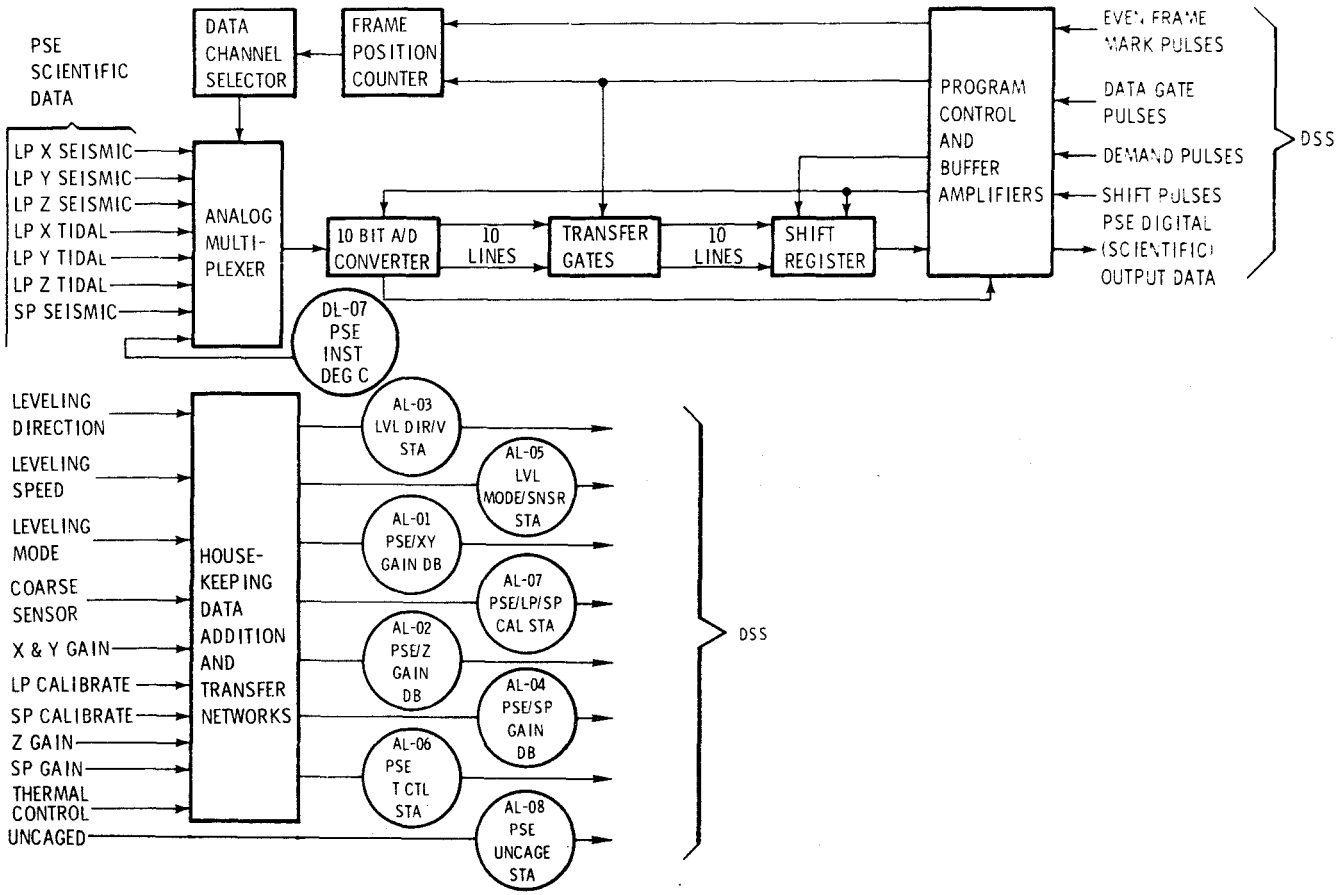
FEB 69 2601 8.4

SHORT PERIOD (SP) SEISMIC FUNCTION



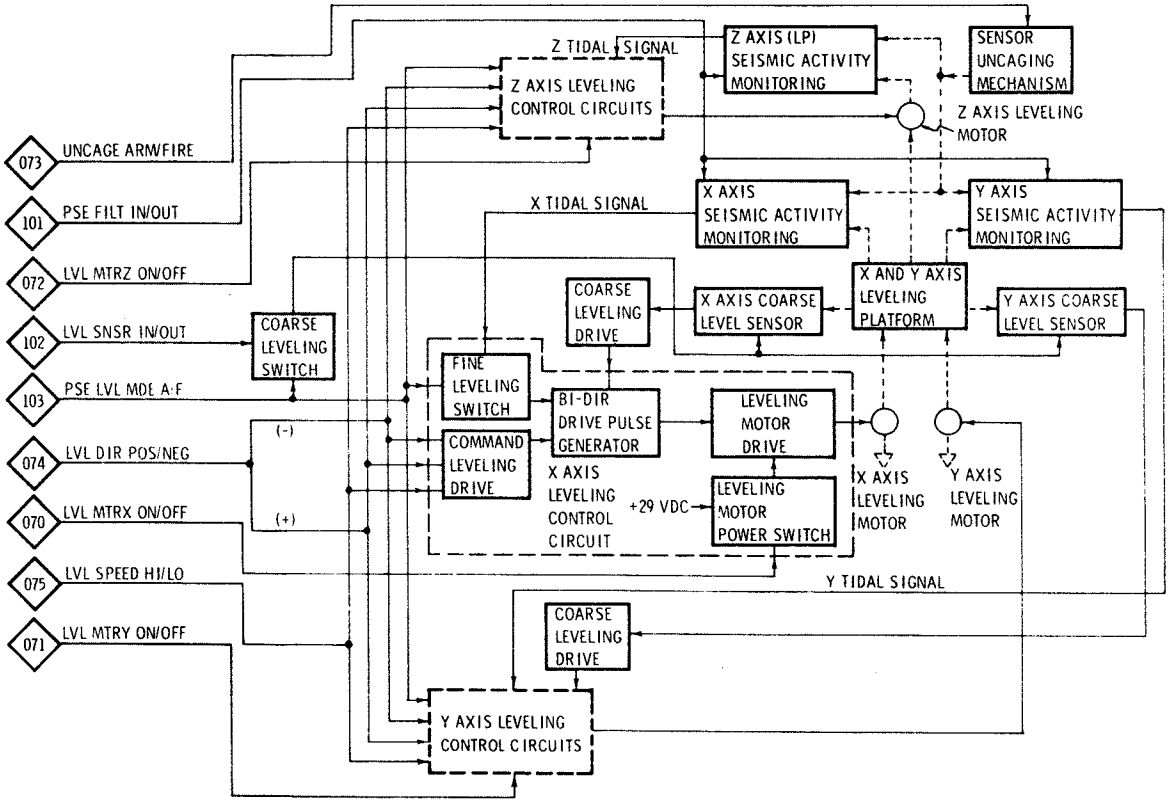
FEB 69 2601 8.5

DATA HANDLING FUNCTION



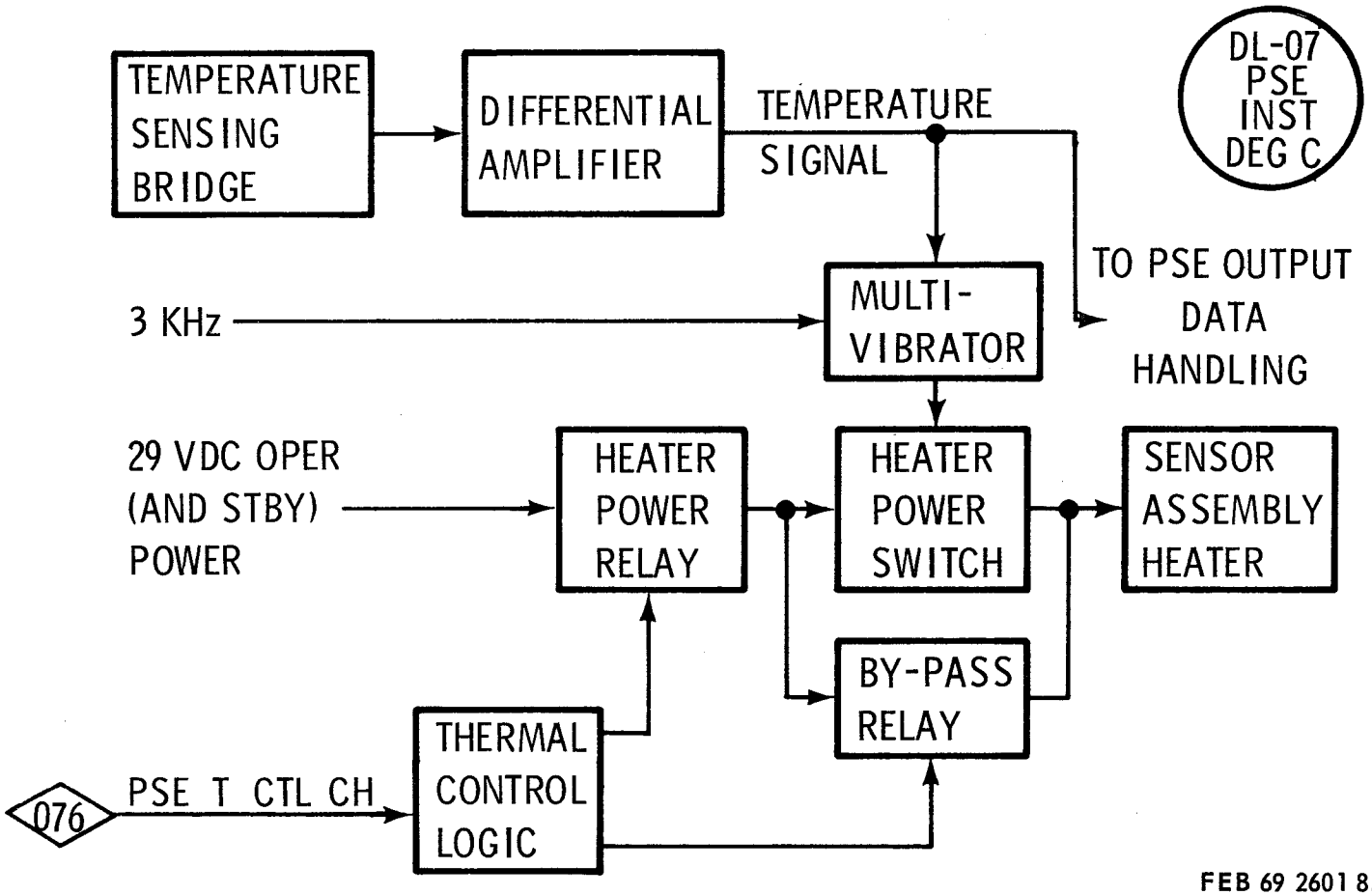
FEB 69 2601 8.6

UNCAGING AND LEVELING FUNCTION



FEB 69 26018.7

PSE THERMAL CONTROL



FEB 69 2601 8.8

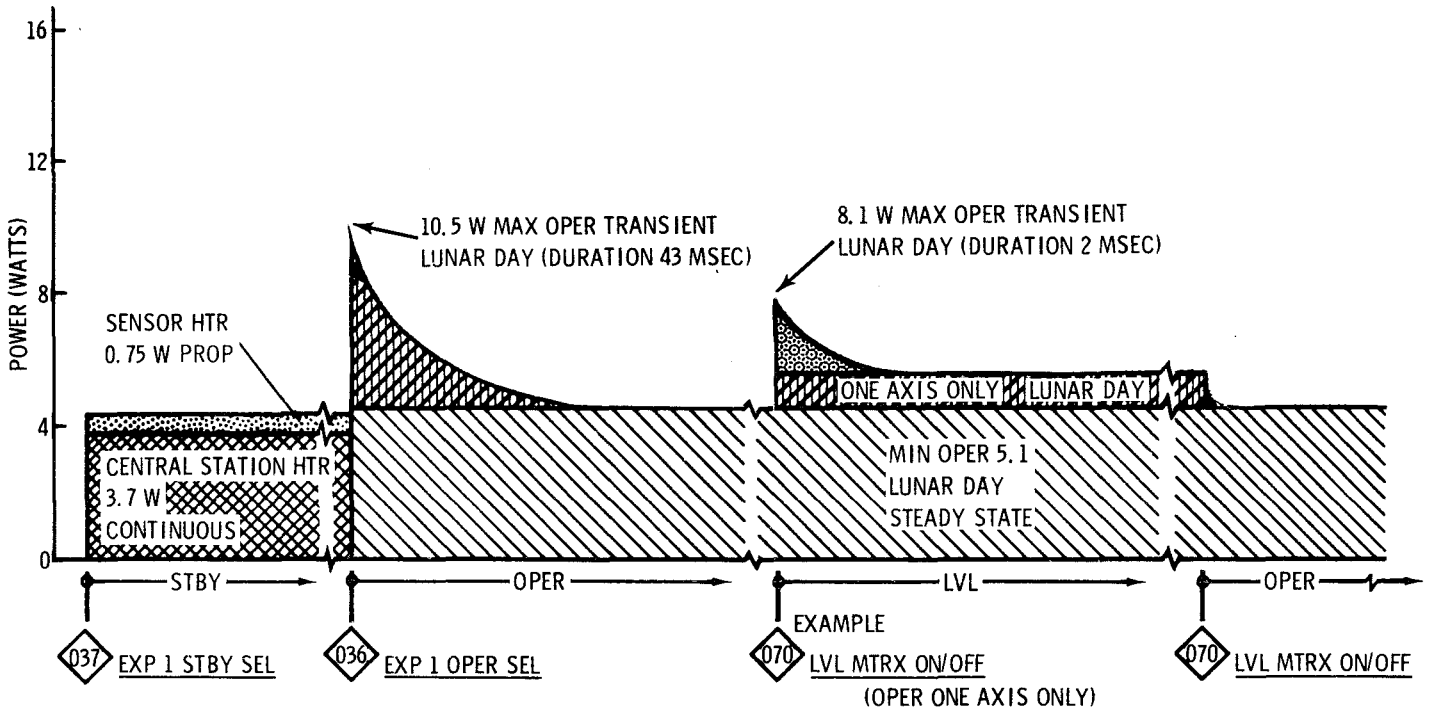
PSE TIMING

TIMING PULSES PROVIDED BY DSS FOR SYNCHRONIZATION AND DATA CONTROL

PULSE	SUBFUNCTION
EVEN FRAME MARK	PROGRAM CONTROL, FRAME POSITION COUNTER, DATA CHANNEL SELECTOR
DATA DEMAND	ALLOWS DATA SHIFT OUT TO DSS
DATA GATE	INDICATES INDIVIDUAL WORDS WITHIN A DATA DEMAND PULSE OF MULTIPLE WORD LENGTH
SHIFT PULSE	TIMING FOR DATA SHIFT-OUT

NOTE: TIMING DOES NOT AFFECT THE PSE POWER PROFILE.

PSE POWER PROFILE



FEB 69 2601 8.10

OPERATING MODES OF PSE

CAGED: PROTECTS EQUIPMENT
PRECEDES OTHER MODES
CANNOT BE RECAGED AFTER UNCAGE

NORM (UNCAGED): DIGITAL SCIENCE DATA (INCLUDING ONE TEMP MEAS FOR DATA INTERPRETATION)
ANALOG ENG DATA

LEVEL: REQUIRED FOR OPTIMUM DATA COLLECTION
MAY BE REPEATED
TWO METHODS • AUTO-SERVO LEVELED
• FORCED-COMMANDED STEPS FROM OBSERVED DATA
NOTE: Z-AXIS "LEVELING" IS ADJUSTMENT OF LACOSTE SPRING

CALIB: THREE DISTINCT FUNCTIONS
- CALIB SP
- CALIB LP X & Y (HORIZ)
- CALIB LPZ

FEB 69 2601 8.11

PSE COMMAND PHILOSOPHY

- COMMANDS ARE INTERRELATED
- LEVELING MODE IS AN EXAMPLE
- ALL THESE CMDS ARE BI-STATE CMDS

OCTAL CMD	CMD	LEVELING MODE			
		AUTO		FORCED	
		COARSE	FINE	FAST	SLOW
103	LVL MDE A/F	A		F	
101	FILT IN/OUT	OUT	IN	OUT	
102	LVL SNSR IN/OUT	IN	OUT	--	
074	LVL DIR POS/NEG	--		POS/NEG	
075	LVL SPEED HI/LO	--		HI	LO
070	LVL MTRX ON/OFF	X		X	
071	LVL MTRY ON/OFF	Y		Y	
072	LVL MTRZ ON/OFF	OR Z		OR Z	

ORDER OPTIONAL BUT MUST BE SET WITH 070, 071, & 072 OFF

AS REQD

SEND LAST BUT ONLY ONE ON AT A TIME. X, Y TO PRECEDE Z

*INDIVIDUAL MOTORS MUST BE CMD OFF AFTER LEVELING AS EACH CONTINUES TO DRAW POWER

*IN FORCED MODE THE LEVEL MOTOR RUNS TO MECH STOP UNLESS CMD OFF

FEB 69 2601 8.12

PSE COMMANDS

OCTAL CMD NUMBER — CMD

063 — PSE/XY GAIN CH

SWITCHES DIFFERENT ATTEN INTO LPX & LPY CKTs TO CONTROL GAIN. REPEATED CMD SUCCESSIVELY STEPS ATTEN THRU VALUES OF 0 DB, -10 DB, -20 DB, -30 DB. CMD CONTROLS CAL CURRENT OF LPX & LPY. ATTEN RESET TO -30 DB UPON PSE ACTIVATION

064 — PSE/Z GAIN CH

AFFECTS LPZ CKT SIMILAR TO 063 ABOVE

065 — PSE/SP CAL CH

APPLIES CURRENT THRU SP CAL ATTEN (SELECTED BY CMD 067) TO SP CAL COIL. SP CAL IS ALSO PERFORMED AUTO EVERY 12 HR UNDER TIMER CONTROL (UNLESS INHIBITED BY CMD 033).

066 — PSE/LP CAL CH

APPLIES CURRENT THRU LP CAL ATTEN (SELECTED BY CMD 063 & 064) TO THE LP DAMPING COILS (3 AXES). CMD IS BI-STATE ON/OFF & IS SET TO OFF UPON PSE ACTIVATION

067 — PSE/SP GAIN CH

AFFECTS SP CKT SIMILAR TO 063 ABOVE

070 — LVL MTRX ON/OFF

APPLIES POWER TO X-AXIS DRIVE MOTOR. CMD IS BI-STATE ON/OFF & IS SET TO OFF UPON PSE ACTIVATION. MOTOR CONSUMES POWER UNTIL CMD OFF.
NOTE: ONLY ONE DRIVE MOTOR TO BE ON AT ONE TIME

071 — LVL MTRY ON/OFF

AFFECTS Y-AXIS SIMILAR TO 070 ABOVE

072 — LVL MTRZ ON/OFF

AFFECTS Z-AXIS SIMILAR TO 070 ABOVE BUT ADJUSTS LACOSTE SPRING

NOTE: DO NOT SEND WHILE EXPERIMENT IS CAGED. WILL DESTROY SENSOR.

073 — UNCAGE ARM/FIRE

IRREVERSIBLE FUNCTION NECESSARY TO OBTAIN PSE SCIENTIFIC DATA. FIRST CMD ARMS. SECOND CMD FIRES ACTUATOR UNCAGING ALL SPRING MASS SYTEMS. SUBSEQUENT CMDs WILL ARM AND THEN ATTEMPT FIRE USING PWR WITHOUT AFFECTING CAGE CONDITION.

OCTAL CMD NUMBER — CMD

074 — LVL DIR POS/NEG

REVERSES DIRECTION OF LEVEL MOTORS LPX, LPY, LPZ IN THE FORCED LEVEL MODE. CMD IS BISTATE POS/NEG & IS SET TO POS UPON PSE ACTIVATION.

075 — LVL SPEED HI/LO

CONTROLS SPEED OF LEVEL MOTORS LPX, LPY, LPZ IN THE FORCED LEVEL MODE. CMD IS BISTATE HI/LO & IS SET TO LO UPON PSE ACTIVATION.

076 — PSE T CTL CH

CONTROLS SENSOR HEATERS BY SELECTING OFF, FORCED-ON, OR AUTO MODES. 4-STATE CMD IS SET TO AUTO UPON PSE ACTIVATION. SUCCESSIVE CMD STEPS THRU MODES IN THIS SEQUENCE:

FORCED-OFF	+29 VDC DISCONNECTED FROM HEATER
FORCED-ON	+29 VDC CONNECTED TO HEATER, AUTO THERMOSTAT CONTROL BYPASSED
AUTO-OFF	+29 VDC DISCONNECTED FROM HEATER
AUTO-ON	+29 VDC CONNECTED TO HEATER, AUTO THERMOSTAT CONTROL ENABLED

- CMD DOES NOT CONTROL HEATER IN PSE CENTRAL STATION ELECTRONICS
- CMD DOES NOT CONTROL SENSOR HEATERS WHEN PSE IS IN EXP 1 STBY SEL (CMD 037).

NOTE: NORMAL PSEP OPERATION WILL BE FORCED-OFF, SET AFTER ACTIVATION.

101 — PSE FILT IN/OUT

REMOVES FEEDBACK LOOP FILTERS FROM LPX, LPY, LPZ. CMD IS BI-STATE IN/OUT & IS SET TO OUT UPON PSE ACTIVATION. FOR PROPER PSE OPERATION, CMD OUT FOR ALL LEVELING EXCEPT AUTO-FINE AND IN FOR CALIB & FOR NORM OPER.
NOTE: DO NOT TRANSMIT THIS CMD WHEN ANY LEVEL MOTOR IS ON

102 — LVL SNSR IN/OUT

ALLOWS COARSE LEVEL SENSORS TO CONTROL LPX & LPY DRIVE MOTORS IN THE AUTO-COARSE LEVEL MODE. CMD IS BI-STATE IN/OUT & IS SET TO OUT UPON PSE ACTIVATION.
NOTE: DO NOT TRANSMIT THIS CMD WHEN ANY LEVEL MOTOR IS ON

103 — PSE LVL MDE A/F

SELECTS LEVELING MODE OF LPX, LPY & LPZ. CMD IS BI-STATE AUTO-FORCED & IS SET TO AUTO UPON PSE ACTIVATION.
NOTE: DO NOT TRANSMIT THIS CMD WHEN ANY LEVEL MOTOR IS ON

PSE MEASUREMENTS

MEASUREMENT NAME	SYMBOL	ALSEP WORD NO'S	ALSEP FRAMES	
PSE/X DATA	DL-01	9, 25, 41, 57	EVERY	SCIENTIFIC
PSE/Y DATA	DL-02	11, 27, 43, 59	EVERY	
PSE/Z DATA	DL-03	13, 29, 45, 61	EVERY	
PSE TIDAL X DATA	DL-04	35	EVEN	
PSE TIDAL Y DATA	DL-05	37	EVEN	
PSE TIDAL Z DATA	DL-06	35	ODD	
PSE INST DEG F	DL-07	37	ODD	
PSE/SP DATA	DL-08	EVERY EVEN EXCEPT 2 , 46, AND 56	EVERY	
PSE/XY GAIN DB	AL-01	33	23	ENGINEERING
PSE/Z GAIN DB	AL-02	33	38	
LVL DIR/V STA	AL-03	33	53	
PSE/SP GAIN DB	AL-04	33	68	
LVL MODE SNSR STA	AL-05	33	24	
PSE T CTL STA	AL-06	33	39	
PSE/LP/SP CAL STA	AL-07	33	54	
PSE UNCAGE STATUS	AL-08	33	69	

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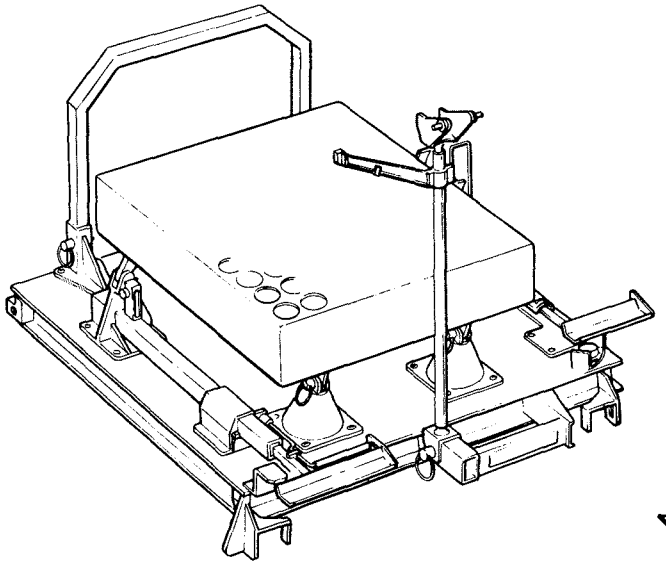
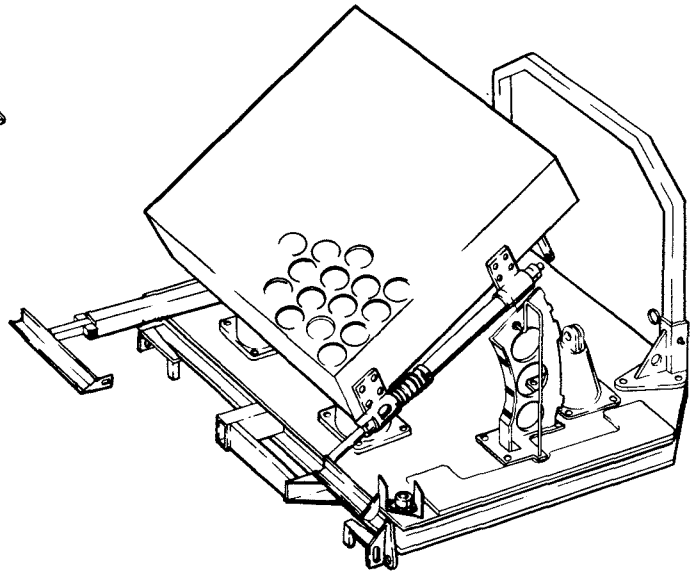
LASER RANGING RETRO-REFLECTOR (LRRR)

STOWED CONFIGURATION



DEPLOYED CONFIGURATION



- PHYSICAL DESCRIPTION
- FUNCTIONAL DESCRIPTION
- OPERATION

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SCIENTIFIC USES OF LRRR

DETERMINE:

- CENTER OF MASS MOTION OF MOON

  SELENOPHYSICAL INFORMATION
  - FORCED PHYSICAL LIBRATIONS
  - LUNAR RADIUS
- GEOPHYSICAL INFORMATION
  - FLUCTUATION IN EARTH ROTATION RATE
  - CHANDLER WOBBLE OF EARTH'S ROTATIONAL AXIS
  - INTERCONTINENTAL DRIFT RATE
- GRAVITY & RELATIVITY
  - VARIATION WITH TIME OF GRAVITATIONAL CONSTANT

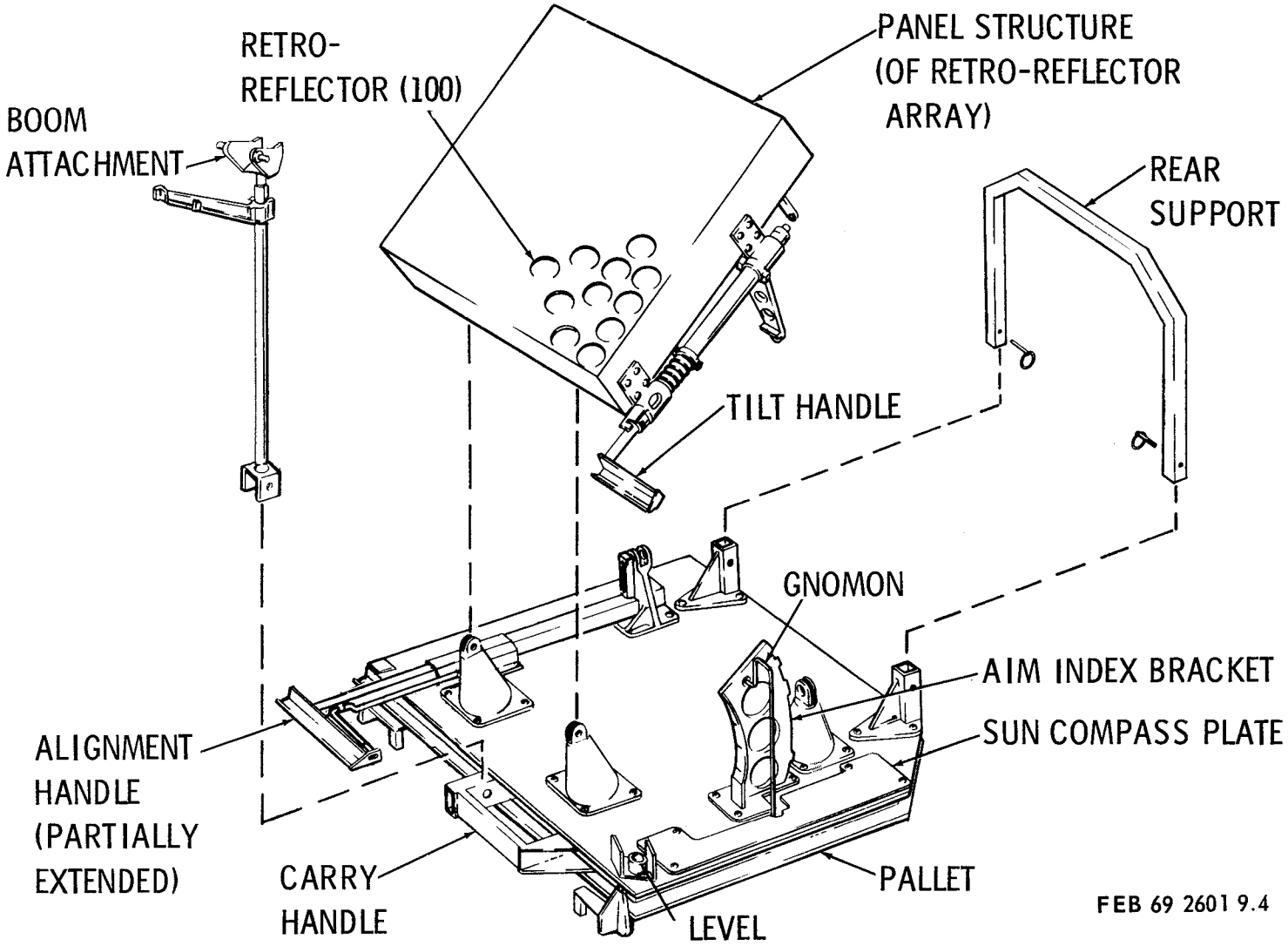
BY MEASURING:

- EARTH-MOON RANGE OVER LONG PERIOD OF TIME (UP TO 10 YEARS)
- RANGE DATA FROM SEVERAL EARTH-BASED LASER SITES
- MOON'S POSITION IN EARTH LONGITUDE (USING EARTH'S ROTATION & SINGLE LASER SITE OR, PREFERABLY, TWO SITES $\approx 90^{\circ}$ APART ON EARTH)

LRRR DESIGN CONCEPT

- RETRO-REFLECTOR ARRAY ON MOON IS AIMED TOWARD EARTH
- LASER RADIATION, FROM EARTH-BASED SITES, IS REFLECTED TOWARD THE SOURCE OF TRANSMISSION
- ACCURACY OF RANGE DATA: 0.1 TO 1.0 METER
- PASSIVE OPTICAL REFLECTOR (REQUIRES NO POWER OR TELEMETRY)
- STRUCTURE/THERMAL CAPABILITY FOR SURVIVAL UP TO 10 YEARS

LRRR MECHANICAL ASSEMBLY



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LRRR MECHANICAL FEATURES

- PROVIDE STRUCTURAL INTEGRITY AND THERMAL CONTROL DURING LAUNCH, FLIGHT, LUNAR LANDING, DEPLOYMENT, & OPERATION IN THE LUNAR ENVIRONMENT
- PROVIDE FOR AIMING & ALIGNMENT OF THE ARRAY

PALLET: TIE-POINTS FOR LM & MOUNTING OF COMPONENTS

BOOM ATTACHMENT: USED IN UNLOADING, THEN REMOVED

REAR SUPPORT: TEMPORARY BASE DURING DEPLOYMENT

CARRY HANDLE: USED IN TRAVERSE TO DEPLOYMENT SITE

AIMING HANDLE & AIM INDEX BRACKET: HANDLE ENGAGES BRACKET; DIFFERENT SETTINGS FOR EACH APOLLO LANDING SITE

ALIGNMENT HANDLE: USED IN ROTATION TO UPRIGHT POSITION & ALIGNMENT TO PROPER SUN COMPASS ANGLE, & LEVELING

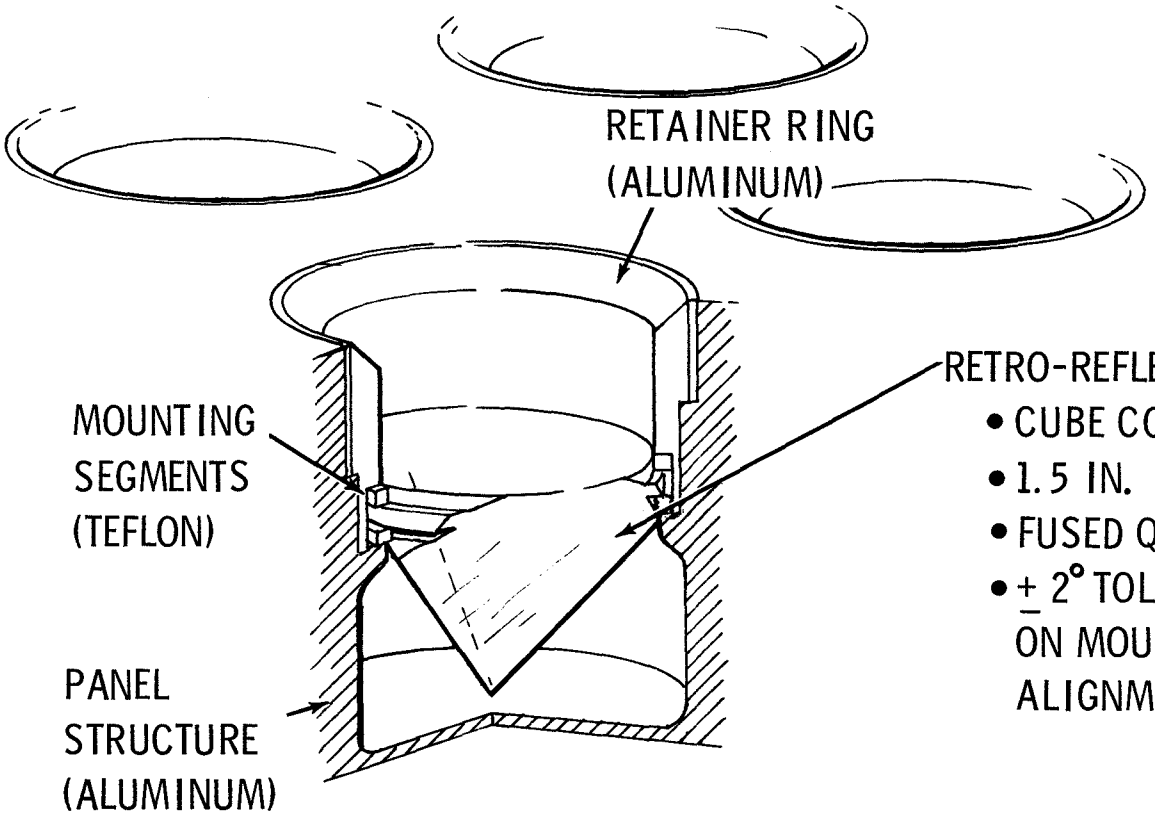
BUBBLE LEVEL, GNOMON, & SUN COMPASS PLATE: INDICATORS FOR ASTRONAUT REFERENCE; GNOMON SHADOW ON PLATE RELATED TO LANDING SITE

PANEL STRUCTURE: SUPPORTS 100 INDIVIDUAL REFLECTORS

LRRR THERMAL FEATURES

- PALLET
  - WHITE THERMAL COATING TO MINIMIZE DAYTIME REFLECTOR THERMAL GRADIENTS
- ARRAY (PANEL STRUCTURE)
  - MACHINED FROM SOLID ALUMINUM BLOCK
  - HIGHLY REFLECTIVE UPPER SURFACE
  - MULTILAYER INSULATION ON SIDES & BOTTOM
  - RELFECTIVE CAVITIES FOR RETRO-REFLECTORS
- RETRO-REFLECTORS
  - RETAINED BY TEFLON SEGMENTS

LRRR RETRO-REFLECTORS



RETRO-REFLECTOR

- CUBE CORNER
- 1.5 IN. DIAM
- FUSED QUARTZ
- $\pm$ 2° TOLERANCE ON MOUNTING ALIGNMENT

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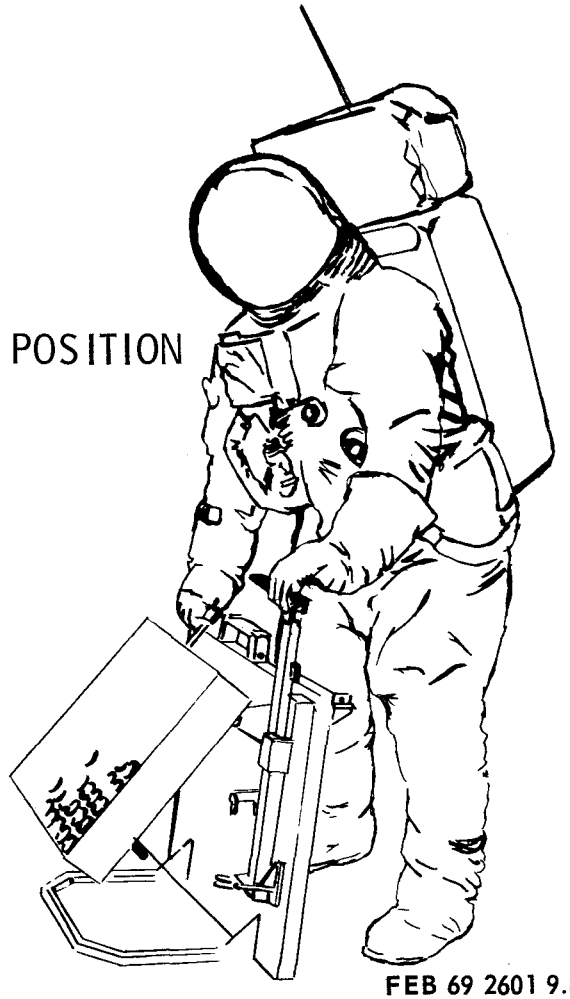
LRRR DEPLOYMENT OPERATIONS

- ROUGH ALIGN
- RELEASE & EXTEND ALIGNMENT HANDLE TO 1ST POSITION
- EXTEND AIMING HANDLE
- PERFORM TILT ADJUSTMENT
- FURTHER EXTEND ALIGNMENT HANDLE
- ROTATE LRRR TO HORIZONTAL POSITION
- ALIGN GNOMON SHADOW
  ON COMPASS PLATE
  & LEVEL PALLET



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LRRR EMPLACEMENT CRITERIA

PARAMETER	REQUIREMENT	INDICATOR	COMMENTS
DISTANCE FROM LM	32 FT (MINIMUM	PACED OFF	CREW/PAYLOAD TRADEOFF
DIRECTION FROM LM	IN FOV OF OTHER ASTRONAUT	EYEBALL	MONITOR DEPLOYMENT (AVOID LM SHADOW AREA)
DISTANCE FROM PSEP	10 FT	PACED OFF	LRRR PROBABLY DEPLOYED FIRST
DIRECTION FROM PSEP	NOT DIRECTLY EAST OR WEST	EYEBALL	TO AVOID SHADOWING SOLAR PANELS
SITE SELECTION	LEVEL & FREE FROM RUBBLE	EYEBALL	CONSTRAINS LEVELING CAPABILITY
TILT OF THE ARRAY	SET TO PROPER POSITION	INDEX MARKS ON SECTOR	DIFFERENT FOR EACH LANDING SITE
LEVEL WRT INDICATOR	$\pm 5^{\circ}$ OF INDICATOR	BUBBLE	INTERACTS WITH ALIGNMENT
ALIGN, WRT SHADOW	$\pm 5^{\circ}$ OF INDICATOR LINE	COMPASS PLATE (PARTIAL ROSE)	ALIGN FOR LANDING SITE
BEFORE ROTATING UPRIGHT FOR FINAL ALIGNMENT LRRR MUST BE FACING AWAY FROM SUBEARTH POINT (FUNCTION OF LANDING SITE)			

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LRRR POST-DEPLOYMENT OPERATIONS

- PASSIVE RETRO-REFLECTOR ARRAY ON MOON AIMED PERMANENTLY AT GENERAL POSITION OF EARTH
- TRANSMISSION/RECEPTION OF LASER BEAM AT EACH EARTH STATION TO OBTAIN EARTH-MOON RANGE DATA
- STATIONS MAY PARTICIPATE IN MULTIPLE-SITE EXPERIMENTS
- PLANNED U. S. STATIONS:
  - AIR FORCE ELECTRO-OPTICAL SURVEILLANCE & RESEARCH FACILITY, CLOUDCROFT, NEW MEXICO
  - ARPA OBSERVATORY, HALEAKALA, HAWAII
- USE BY FOREIGN SCIENTISTS IS ANTICIPATED

EASEP ABBREVIATIONS

a	ampere
AB	Analog Bistatic (Discrete) Measurement (Code)
AC	Alternating Current
ACCEL	Acceleration
ACCPT	Accept
ACK	Acknowledge
ACN	Ascension Island (MSFN)
A/D	Analog to Digital
ADC	Analog-to-Digital Converter
ADD	Address
ADJ	Adjustment
ADV	Advance
AE	Analog Electrical Parameter (Code)
AEC	Atomic Energy Commission
A/F	Automatic/Forced
AGC	Automatic Gain Control
AIM	Aiming
ALSEP	Apollo Lunar Surface Experiments Package
ALT	Alternate
AMPL	Amplifier
AMP	Amperes-pl is AMPs Amplifier(s)
AMU	Atomic Mass Unit
ANT	Antenna
APPROX	Approximate, Approximately
ARC	Ames Research Center
ASI	Apollo Standard Initiators
ASSY	Assembly
ASTRO	Astronaut
AT	Analog Temperature Parameter (Code)
ATTEN	Attenuator
AUTO	Automatic
AWG	American Wire Gage
AZ	Azimuth
B1	Bottom Location of Structure Temperature Measurement
BATT	Battery
BER	Bit Error Rate
BIOMED	Biomedical
BKG	Background
BPS	Bits per Second
BTU	British Thermal Unit
C	Centigrade
CAL	Calibrate, Calibration
CAP	Capacitor
CDP	Command Data Processor
CFE	Contractor-Furnished Equipment
CG	Center of Gravity
CH	Change, Channel (Data)
CIRC	Circular
CKT	Circuit
CKT BKR	Circuit Breaker
CLD	Cold
CMD	Command (CMDs, Commands) Commanded
CNB	Canberra, Australia (MSFN)
CNT(s)	Count(s)
CNTR	Counter
COAX	Coaxial Cable
CON	Connector
COMM	Communications
CONFIG	Configuration
CONN	Connection
CONT	Controlled-Control (Cont. = Continued)
CONV	Converter
CPS	Cycles per Second
CRT	Cathode Ray Tube
CTL	Control
CUR	Current

CV	Command Verification
CVR	Cover
CW	Clockwise
db	Decibels
dbm	Decibels, with reference to one milliwatt
DC	Direct Current
DDP	Digital Data Processor
DECOM	Decommutate, Decommutation
DEF	Deflection
DEG	Degrees
DEMOD	Demodulator
DET	Detect, Detection, Detector
DIAM	Diameter
DIR	Direction
DIR/V	Direction and Speed (Used on PSE)
DISSIP	Dissipation
DIST	Distribution
DSS	Data Subsystem; components include: DSS/A Analog Data Processor DSS/D Digital Data Processor DSS/PROC Complete Data Processor (Redundant)
E	East
ea	Each
EL	Elevation
ELECT	Electrical
ELEV	Elevation
EM	Electromagnetic
EMI	Electromagnetic Interference
ENG	Engineering
EOS	Electro-Optical Systems (Xerox)
EPS	Electrical Power Subsystem
EQUIP	Equipment
EQUIV	Equivalent
ev	Electron Volts
EVA	Extravehicular Activities (or Astronaut)
EXP	Experiment
EXPER	Experiment
EXT	External
F	Fahrenheit, Flight
FEP	Fluorinated Ethylene Propylene
FET	Field Effect Transistor
FILT	Filter
FLD	Field
FREQ	Frequency
FT	Foot
FWD	Forward
g	Gravity
GAL	Gravity (used as μ gal on PSE)
GDS	Goldstone, California (MSFN)
GEN	Generator
GFE	Government-Furnished Equipment
GHz	GigaHertz
GMT	Greenwich Mean Time
GND	Ground
GSFC	Goddard Space Flight Center
GWM	Guam (MSFN)
HAW	Kauai Island, Hawaii (MSFN)
HI	High
HK	Housekeeping
HORIZ	Horizontal
HR	Hour
H/S	High Speed
HTR	Heater
HV	High Voltage
Hz	Hertz
ID	Identification
IF	Intermediate Frequency
IN	Input
IN.	Inch
INC	Including, Included, Increase

INHIB	Inhibit
INST	Instrument
INSUL	Insulation
INT	Internal
INTEG	Integrator
ISO	Prefix meaning "single"
JPL	Jet Propulsion Laboratory
K	Kelvin, Kilo
KBPS	Kilobits per Second
kev	Kilo-Electron Volts
KHz	KiloHertz
KSC	Kennedy Space Center
KV	Kilovolt
KW	Kilowatt
LB	Pound (LBs, plural)
LBR	Low Bit Rate
LM	Lunar Module
LO	Low
LOG	Logarithmic
LP	Launch Phase, Long Period (PSE)
LRRR	Laser Ranging Retro-Reflector
LSB	Least Significant Bit
LV	Low Voltage
LVL	Level
M	Meter
MA	Milliampere
MAD	Madrid (MSFN)
MAP	Message Acceptance Pulse
MAX	Maximum
MCC	Mission Control Center
MDE	Mode
MEAS	Measurement
MECH	Mechanical, Mechanism
MEG	Million (as in Megohm)
MFG	Manufacturing
MHz	MegaHertz
MIN	Minimum, Minute
MISC	Miscellaneous

LUDE
Lunar Deboost Degradation Engr

MON	Monitor (ing
MS	Millisecond (also MSEC)
MSB	Most Significant Bit
MSC	Manned Spacecraft Center
MSEC	Millisecond
MSP	Measurement Sequence Programmer
MSFN	Manned Space Flight Network
MTG	Mounting
MTR	Motor; on PSE, the three motors are MTRX, MTRY, and MTRZ
MUX	Multiplexer
MV	Millivolt
mw	Milliwatt
NW/CM2	Milliwatts per Square Centimeter
mμ	Millimicron
N	North, Number
NA	Nano Amperes, Not Applicable
NASA	National Aeronautics and Space Administration
NBR	Normal Bit Rate
NEG	Negative
NG	No Good
Ni	Nickel
NO.	Number
NORM	Normal
NRC	National Research Corporation
NRZ	Non-Return to Zero
OPER	Operate, Operation, Operating, Operator, Operational
O/S	Offset
OSC	Oscillator
O/T	One-Time
OUT	Output
PARAM	Parameter
PCB	Printed Circuit Board
PCM	Pulse Code Modulation
PCT	Percent

PCU	Power Conditioning Unit
PDR	Power Dissipation Resistor
PDU	Power Distribution Unit
Pe	Probability of Bit Error
PERF	Performance
PF	Picofarad
PKG	Package
PL	Plane
PLSS	Portable Life Support System
PM	Phase Modulation
POS	Positive
POSN	Position
PREAMP	Preamplifier
PRELIM	Preliminary
PRE/LIM	Pre-Limiting
PRI/ST	Primary Structure
PROP	Proportional
PROC	Processor
PROG	Programmer
P/S	Power Supply
PSE	Passive Seismic Experiment; also: PSE/LP Long Period Sensors PSE/SP Short Period Sensor PSE/LP/SP Long and Short Period Sensors Long Period Sensors are further defined as PSE/X, PSE/Y, and PSE/Z while PSE/XY denotes the two horizontal long period sensors
PSI	Pounds per Square Inch
PSIA	Pounds per Square Inch Absolute
Pu 238	Plutonium Isotope
PWR	Power
QTY	Quantity
R	Resistor (used as R1 and R2)
RAD	Radians
RAD/SEC^2	Radians per Second per Second
RCVD	Received
RCVR	Receiver
REF	Reference
REG	Regulator, Register
REP	Repetition
REQD	Required
REQMT	Requirement (REQMTs, pl)
RES	Reserve
RNG	Range
ROT	Rotation, Rotate
RST	Reset
RT	Rate (as in BIT RT, CNT RT, etc.)
RTC	Real Time Command
RTE	Real Time Event
RTN	Return
S	South
S/C	Spacecraft
SCAS	Southwest Center for Advance Studies
SCI	Scientific, Science
SEC	Second
SEL	Select, Selector, Selection
SEQ	Sequence, Sequential, Scientific Equipment (a Bay in LM)
SIG	Signal
SLA	Spacecraft/LM Adapter
SMEK	Summary Message Enable Keyboard
S/N	Signal to Noise
SNSR	Sensor
SOS	Space Ordnance Systems, Inc.
SP	Split Phase, Short Period (PSE)
SPEC	Specification
SPST	Single Pole, Single Throw
SRC	Specimen Return Container
S/T	Structure/Thermal

STA	Status, Station (Cent Sta)
STBY	Standby
SW	Switch
SYNC	Synchronization (abbreviated "SY" on APOLLO)
T	Temperature
TAPLE	Telemetry for Apollo Passive Lunar Experiments
TBD	To Be Determined
TEMP	Temperature (TEMPs, pl)
TERM	Terminal
TM	Telemetry
TMR	Timer
TNT	Trinitrotoluene
TORR	Unit of Pressure (one Millimeter of Mercury)
TRANS	Transmitter
TRW	TRW, Inc. (Manufacturer)
TV	Television
USGS	United States Geological Survey
UV	Ultraviolet
V	Volt, Velocity (used to indicate "Speed" on PSE in "LVL DIR/V")
Vcc	Transistor Supply Voltage
VCO	Voltage Controlled Oscillator
VDC	Volts Direct Current
VERT	Vertical
V/FILT	Velocity Filter
V/M	Volts per Meter
VSWR	Voltage Standing Wave Ratio
W	Watt, West
WD	Word (WDs, pl)
WRT	With Respect To
WT	Weight
XMTR	Transmitter
YR	Year
μGAL	Microgal
μSEC	Microsecond